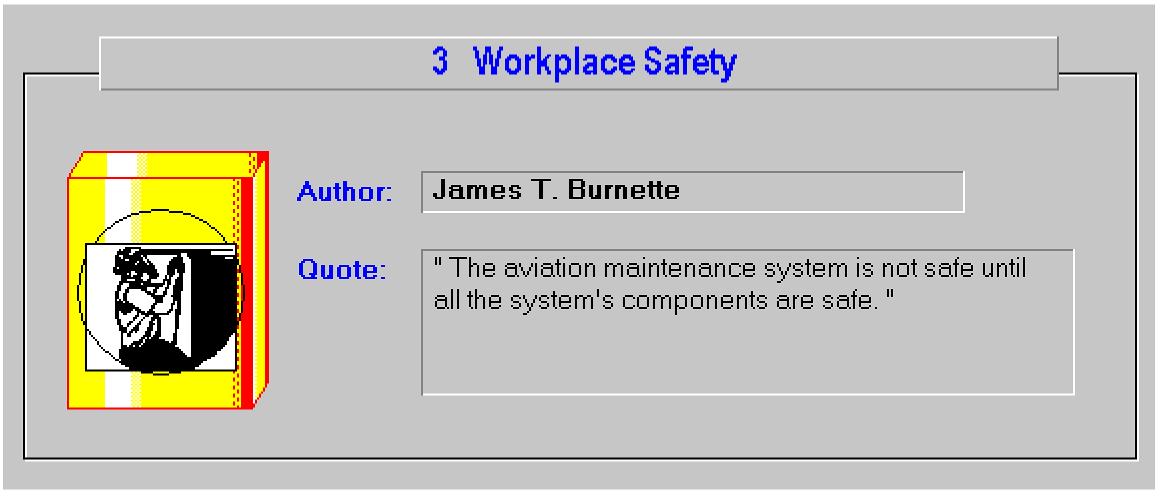
Chapter 3
WORKPLACE SAFETY



INTRODUCTION

The aviation industry is well aware of the concept of system safety. Supporting and enhancing the continued safety of the flying public underlies nearly all training, regulation, and working procedures in the industry. Most of this emphasis, however, is placed on the airworthiness of equipment and crews. Safety is also relevant to the maintenance workplace. The aviation maintenance system is not safe until all of the system's components are safe, including the maintenance workers.

Unsafe maintenance system elements increase operating costs and reduce efficiency and effectiveness. Additional costs may arise from Workers' Compensation or health insurance claims or premiums, from regulatory fines, from lawsuits, from labor grievances, and from increased investigative or training requirements. Maintenance effectiveness suffers when there is a shortage of qualified people, such as Aviation Maintenance Technicians (AMTs), or if these people are concerned about their personal health and safety.

Apart from the monetary impact of poor safety on the organization and the potential for compromising the safety of aircrews and the flying public, there is the very real human cost to the maintainers. We sometimes tend to lose sight of the pain and suffering, psychological and family stress, lifestyle and quality-of-life adjustments, and career-shortening implications of workplace injuries. These points are brought into sharp focus whenever those injured in workplace accidents recount their experiences.[1]

Though the aviation industry is constantly searching for ways to reduce costs and increase productivity, there are societal trends that make this a challenge. These legal, ethical, financial, and humanitarian trends also increase workers' expectations about their personal safety and health. Since there are probably no risk-free jobs, managing the residual effects of risks has become as important as eliminating hazards to reduce risk.

Human Factors addresses the characteristics of human workers and their environment that affect performance. Workplace safety is directly related to workers' ability to perform their jobs without making errors. Thus, human factors methods can be used to reduce errors and increase safety.

In this chapter, we discuss the major human factors issues related to aviation workplace safety. Our focus here is the safety of the workers themselves, not equipment airworthiness, although these two issues are directly related. We cannot provide enough information in this *Guide* for readers to develop a complete workplace safety program. Workplace safety is a very complex topic. There is enough information in the chapter, however, to allow readers, *with proper professional assistance*, to determine if existing or planned workplace safety programs attend adequately to the human component.

BACKGROUND

Early aviation maintenance operations focused entirely on ensuring that airplanes flew when needed. As these operations gained experience, they developed increasingly sophisticated procedures to guarantee this result. There was no organized responsibility for airplane safety at that time. There was probably even less systematic concern for safety in the maintenance workplace.

In 1967, the US Government created the Federal Aviation Administration (FAA) in the Department of Transportation.[2] Its stated goal was to improve the standardization of procedures throughout the aviation industry. Responsibility for workplace safety was implicit in the authorizing act, but was not explicitly assigned.

With the creation of the Occupational Safety and Health Administration (OSHA) in 1970, Congress indicated its intention to improve the health and safety of all workers in the United States.[3] A 1982 list of the leading work-related diseases and injuries is shown in Table 3-1.[4] During the process of creating the act, Congress specifically excluded several groups of workers already covered by existing laws. Generally, they excluded, without direct reference, any group under the jurisdiction of another federal government agency, including the aviation industry under the FAA. Many of these otherwise excluded organizations have worked with OSHA anyway, especially in the area of workplace safety.

Table 3-1. Leading work-related diseases and injuries in the US in 1982.

1. Lung disease
2. Musculoskeletal injuries
3. Cancers
4. Acute trauma
5. Cardiovascular disease
6. Reproductive disorders
7. Neurotoxic disorders
8. Hearing loss
9. Skin conditions
10. Psychological disorders

The current trend is for OSHA and other regulatory agencies to cooperate with each other in establishing safe workplaces. Since OSHA has a relatively small number of inspectors, it is conceivable that FAA inspectors will have additional workplace safety responsibilities in the future. If this comes to pass, OSHA will undoubtedly train and coordinate the activities of these new workplace inspectors.

The anticipated shortage of qualified AMTs necessitates a serious program of broader recruitment (to include more females and minorities) and improved retention throughout the aviation industry.[5] Successful aviation maintenance operations understand that workplace safety is a key element in recruiting and retaining.

ISSUES AND PROBLEMS

General trends in society also affect the aviation industry. Though the safety problems present in the maintenance environment are not unique, they may have different priorities than in other industries. For instance, a recent report lists the following three environmental problems as the most important for AMTs:[6]

- Inadequate lighting, particularly underneath an aircraft's fuselage or wings
- Noise, especially short-term impact noise, such as from riveting
- Ambient temperature resulting from the open floor plan associated with hangars.

This report also mentions work support systems (work platforms, for instance), the use of composite materials, and non-day work schedules as concerns in the industry. The report recommends using Health and Safety committees as an effective way of dealing with these, and other, workplace issues.

Workplace safety depends upon a combination of complete, systematic preparation and responsible individual behavior. The comprehensive list of workplace safety issues shown in Table 3-2 reflects the complexity of the modern workplace. Ignoring one or more of these issues could impair an otherwise effective safety program and reduce the organization's ability to maintain aircraft reliably.

Individual Issues

The human component of the maintenance system is incredibly adaptable, but not infallible. System design that depends on the human user to compensate for design deficiencies is doomed to a life of increased errors and marginally effective performance. It is better to design a system that utilizes the capabilities of the individual(s) without imposing unnecessary limitations. It is sometimes essential to improve a person's capabilities through training or conditioning. This is one reason AMT training programs may become longer and more focussed.

Task-Related Issues

Some tasks are notoriously inappropriate for humans. As for any other system component, if we overload the human, we should expect reduced effectiveness and possible failure or injury. It is also possible to "underload" a person and thereby reduce his or her productivity. Tasks such as painting a fuselage may underwork much of the body while overworking the hands and arms.

Tool and Equipment Issues

Table 3-2. Categories of workplace safety issues.

Individual
Task-Related
Tools and Equipment
Facilities and Environment
Materials
Administrative/Organization

In order to optimize any human-machine system, it is necessary to design tools and equipment for the individual person. Though it is common for people to be able to design for themselves, it is difficult to design for everyone else. For example, as the aviation industry recruits more female AMTs, it will become important to provide tools made to fit a smaller hand.

Facilities and Environment Issues

There is ongoing concern about the lighting, noise, and ambient temperatures associated with aviation maintenance. Each of these variables can reduce workers' effectiveness and increase the risks of accident, injury, or possible work-related illness. It is necessary to control these, and any other relevant factors during the design and everyday use of the working environment. Failing to address facility issues can easily increase work and inspection errors.

Materials Issues

Misusing or inappropriately storing hazardous materials can cause both chronic and acute symptoms . One report on this topic maintains that "all employees have a right to know the chemical name and properties of the hazardous substances they are working with and how to handle them safely."[7] There are specific regulatory requirements related to communicating hazardous material characteristics (see Materials Issues in the Guidelines Section). Unfortunately, it is easy to fall into a false sense of security when using these materials every day (see "Habituation in Chapter 1). Such a lack of concern for dangerous materials commonly results in injuries. For example, an AMT might carelessly leave open the cover protecting the degreaser bath, allowing someone else to splash the degreasing solution into his or her eyes.

Administration/Organization Issues

Management decisions sometimes start a chain reaction of events that can produce unpredictable results. It is difficult to change any feature of the workplace without creating short-term surprises, even if the change will lead to long-term improvement. Not all people have the same priorities and values, so it can be difficult to coordinate a safe working system. Also, the intent of many policies is dictated by law, but the precise wording and the local interpretation and implementation are not. The range of company actions in response to the Americans with Disabilities Act (ADA) provides an example of the variation in responses to a single law.[8]

REGULATORY REQUIREMENTS

Workplace safety is a broad issue regulated by a number of federal, state, and local agencies. In the aviation maintenance environment, there are three federal agencies directly or indirectly involved in workplace safety-the Environmental Protection Agency (EPA), the Federal Aviation Administration (FAA), and the Occupational Safety and Health Administration (OSHA). While not directly involved in regulation, the American National Standards Institute (ANSI) is the primary consensus standards organization in the United States. Regulatory bodies responsible for workplace safety frequently invoke many ANSI standards.

Environmental Protection Agency (EPA)

Established in 1970 to coordinate government actions on behalf of the environment, EPA administers acts of Congress dating back to the Refuse Control Act of 1899. The legislation most relevant to the aviation industry includes the Resource Conservation and Recovery Act (RCRA)[9] and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (known as "Superfund"),[9] amended in 1986. These two acts set up procedures for reporting and controlling hazardous materials and for using protective equipment to protect individuals and the environment.

Title 40 of the Code of Federal Regulations (CFR), Protection of Environment, provides a comprehensive explanation of federal environmental protection legislation.

Federal Aviation Administration (FAA)

The FAA is responsible for ensuring the health and safety of the flying public by setting training requirements for both operating crews and maintenance workers. The FAA approves all major maintenance procedures and periodically inspects both the facilities and people involved in aircraft maintenance. The FAA is officially authorized to perform its role by Title 14 CFR. Parts 1-199 of Title 14 CFR are known as the Federal Aviation Regulations (FARs).

Workplace safety traditionally has not been a primary concern of the FAA , except where unsafe working conditions might also affect the safety of aircraft or crews. The FARs contain no rules related directly to workplace safety. In the FAR description of the certificate holder's Operations Manual [Part 121.135 (a)(1)], an ambiguous statement requires that the Manual "Include instructions and information necessary to allow the personnel concerned to perform their duties and responsibilities with a high degree of safety...". It is not clear whether this requirement refers to the safety of the maintenance workers, the safety of aircrews and the flying public, or is inclusive. The lack of further FAR requirements related specifically to worker safety is probably indicative of the lack of such emphasis.

The locus of responsibility for the workplace safety of aircraft maintainers is not clear-cut. OSHA ordinarily would be the federal agency responsible for such safety matters. However, OSHA generally defers to other federal agencies who oversee groups of workers. It appears that OSHA and the FAA are destined to cooperate in their efforts to ensure aviation workplace safety.

Occupational Safety and Health Administration (OSHA)

The 1970 Occupational Safety and Health Act created the Occupational Safety and Health Administration (OSHA), its research-oriented sister organization the National Institute for Occupational Safety and Health (NIOSH), and the Occupational Safety and Health Review Commission (OSHRC) to review enforcement decisions.[10] All OSHA regulations are contained in Title 29 CFR, Chapter XVII, Parts 1900-1999. All employees in territories under the jurisdiction of the United States Federal Government are covered by the act. There are some exemptions for employees covered by other government agencies, if these agencies are actively involved in employee protection.

American National Standards Institute (ANSI)

ANSI coordinates voluntary (consensus) standards in the United States for all segments of our economy. It represents the United States internationally through the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the Pacific Area Standards Congress (PASC). Originally named the American Standards Association, ANSI evolved during 1920 from the American Engineering Standards Committee's (AESC) need for an additional emphasis on safety.[11]

ANSI is comprised of 1200 national trade, technical, professional, labor, and consumer organizations, government agencies, and independent companies. Health and safety standards usually arise from ANSI-accredited Standards Committees. The Williams-Steiger Occupational Safety and Health Act of 1970 emphasized just such a standard-setting process.

State Agencies

There may be additional agencies with authority over workplace safety. Examples include the following:

- local fire departments
- state licensing boards
- planning commissions.

CONCEPTS

There are a number of concepts associated with workplace safety. As noted below, some of these concepts are based on incorrect common wisdom. Others are useful for discussions later in the chapter.

Accident Proneness

Accident proneness suggests that certain individuals are involved in more accidents than others because of some innate predisposition. This concept has been generally discredited in the safety community. It is attractive to many people in positions of responsibility because it implies that people involved in accidents are completely culpable for their own injuries. In fact, accidents occur because of inadequate design, poor preparation, or personal limitations, not because of individual predisposition.

Compliance

To be "in compliance" means that one acts in accordance with all applicable rules and standards. This is necessary, but not sufficient in all cases, to prevent accidents and injuries. Rules and standards often represent minimum requirements or may be restricted to a narrow scope. They may become outdated by advances in technology or changes in working procedures.

Consensus Standards

Consensus standards must be agreed to by all affected parties. Most standards development groups are populated by representatives from a variety of commercial organizations. These organizations may not want to allow standardized requirements that jeopardize their business practices. Thus, consensus standards are likely to represent the lowest common denominator among its developers and may or may not be technically adequate.

Criminal Negligence

Negligence has various legal meanings and connotations (see Negligence). Most negligence is associated with tort law, in which only civil, i.e., monetary, penalties are applied. However, negligence can be elevated into criminal law. Criminal negligence is the failure to use a reasonable amount of care when such failure results in injury or death to another. This failure can occur in design, training, operation, etc.

Criterion-Based Standards

Criterion-based standards require that certain strict, rigid, and objective criteria be met in order to be in compliance. Certain OSHA standards, such as those that specify Threshold Limit Values for certain toxins,[12] are criterion-based. Contrast these standards with performance-based standards.

Dangerous

Dangerous means risky, hazardous, or unsafe. In the safety profession, situations, tools, or other elements can be either of the following:

- *Imminently* dangerous-impending or immediate risk, such as a bare electrical cord
- *Inherently dangerous*-usually risky, such as poisons or explosives.

"de minis" Violation

Regulatory agencies do not treat all rule violations equally. A "de minis" violation occurs when there is non-compliance with a rule or standard, but that violation doesn't immediately or directly affect a person's safety or health.

Design for the Individual

While we are used to thinking in terms of "averages," there really are no average people. Each person has different body dimensions, strength, abilities, and limitations. The human factors design and evaluation processes consider these individual requirements. A safe work environment necessarily considers the safety of each individual worker.

Experience Rating

There are various methods of setting insurance or tax rates for industrial organizations. *Experience rating* means basing such rates on an organization's record of claims and payments.

Failure

Failure is a general term that means the inability to perform an intended task or function. Any system component - human, procedural, or automated - can fail. In the systems view of aviation maintenance, the maintenance process is only as reliable as its weakest component. Even the failure of a seemingly unimportant element can cause the overall system failure.

Failure Management

To paraphrase a bit of commonly accepted wisdom, "Stuff happens!" Over the life of a system, certain failures are likely to occur. Failure management is the process of planning, setting policies, and making decisions that identify and eliminate (or control) potential failures and implementing corrective or control procedures after actual failures.

General Duty Clause

General Duty Clause refers to a comprehensive requirement in the OSHA regulations for every employer to provide work and a workplace free from recognized hazards.[3] This is meant to put employers on notice that they have a general duty regarding their workers' safety.

Hazards

A *hazard* is a dangerous condition that can interrupt or interfere with the expected, orderly progress of an activity. The Department of Defense recognizes four classes of hazards:[13]

- Negligible - will not result in injury to people or serious damage to equipment
- Marginal - can be controlled to prevent injury or damage
- Critical - will cause injury or serious damage (or both)

- Catastrophic - will cause death to workers.

Human Reliability

The essence of the concept of *reliability* is repeatability. If something is reliable, it can be counted on to do the same thing over and over in the same manner. The opposite of reliability is variability. Humans are notoriously variable. We tend not to do the same thing twice in the same manner or like another person. While we prize our individuality, the major cause of human error is human variability.[14]

Job Safety/Hazard Analysis

Job Safety Analysis (JSA), or Job Hazard Analysis (JHA), is a technique used to determine the hazards connected with a job or task. It is used to develop controls for these hazards and to devise the requirements or qualifications of those workers who will perform the job or task. JSA/JHA reduces the job or task into subtasks or activities for analysis.[15]

Loss Control

Loss Control is the name given to a range of programs designed to minimize accident-based financial losses. Insurance companies often mandate loss control programs, which are usually some combination of on-site, checklist inspections and an analysis of "near misses" (see Critical Incident Technique).

National Institute for Occupational Safety and Health (NIOSH)

NIOSH is the sister agency to OSHA located in the Department of Health and Human Services. Both NIOSH and OSHA were created at the same time.[3] NIOSH does not directly develop rules or regulations but is responsible for research into the causes of and cures for occupationally caused injuries and illnesses. OSHA may require extensive technical assistance from NIOSH in the form of Health Hazard Evaluations when the causes of health or safety problems are unknown or complex.

Negligence

Negligence is acting with a lack of reasonable conduct or care. There are three main types of legal negligence:

- Actionable negligence - breach or non-performance of a legal duty that results in injury or damage
- Comparative negligence - both (or all) parties are negligent and compensation is diminished proportionally
- Contributory negligence - compensation for injury or damage is reduced or eliminated because the complainant knowingly took an unreasonable risk, which resulted in the injury or damage.

Occupational Safety and Health Administration (OSHA)

OSHA is the federal agency created by the Occupational Safety and Health Act of 1970.[3] Located in the Department of Labor, OSHA is responsible for establishing and enforcing federal workplace safety and health standards. Many states administer their own occupational safety and health programs. This is allowed under the Occupational Safety and Health Act, so long as these state-run programs meet or exceed federal standards. OSHA standards are published in the Code of Federal Regulations (CFR), Section 29, Subsections 1910-1926.

Performance-Based Standards

Performance-based standards identify important, broadly-defined goals that must result from applying a standard, rather than specific technical requirements. Recent OSHA regulations, such as the confined space entry standard, are performance-based standards.[16] Contrast these with criterion-based standards.

Surveillance

Surveillance refers to a number of techniques for analyzing and monitoring the workplace to identify safety-related problems. There are two types of surveillance:

- Passive - using existing records, including medical, insurance, OSHA, and production logs, to detect developing health or safety problems
- Active - investigating the work, workplace, tools and equipment, materials, or environment to learn the causes of and solutions to problems uncovered during passive surveillance.

Systems Approach

The systems approach considers humans to be part of an integrated system, not external to or isolated from the total environment (see Chapter 1 for more detail).

System Safety

System safety should result when a systems approach is used to address safety. It requires applying design, operating, technical, and management techniques and principles throughout the life of a system to reduce hazards to their lowest practical levels (see Chapter 1 for a further discussion of system concepts).

Workers' Compensation

Workers' Compensation is a system of insurance required by state law. It is usually financed by employers and provides payments to employees or their dependents for occupational illness, injuries, or fatalities, regardless of fault. As part of the state laws mandating workers' compensation insurance, employers are generally protected from individual personal injury litigation. The scope of such protection varies from state to state.

METHODS

There are many methods that can be applied to workplace safety. In fact, most of the general human factors methods described in Chapter 1 are applicable, one way or another, to workplace safety. Certain methods are routinely associated with safety. The primary safety methods are described in this section.

Critical Incident Technique

The Critical Incident Technique is used in a variety of human factors applications. It is a general human factors method. In essence, the Critical Incident Technique asks people who work in a particular environment to report equipment, practices, or other people that cause, or almost cause, accidents. The Critical Incident Technique can be implemented as either a written or oral process i.e., we can ask people to supply their reports in writing or in face-to-face interviews. Most people are reluctant to report even grossly unsafe acts if they have to implicate their co-workers or, especially, themselves.

Because of people's reluctance to report unsafe behavior, successful critical incident reporting systems allow reporters to maintain their anonymity. One of the oldest and most successful programs of this nature is the Aviation Safety Reporting System (ASRS).[17] The ASRS allows aircrew members, and others, to confidentially report incidents or near-incidents.

The Critical Incident Technique is based on the assumption that the people who spend every working day in a particular work environment know about the unsafe elements in that workplace. While this is not universally true, it is certainly the case that workers see many of the behaviors and equipment characteristics that **almost** cause accidents. This information is quite useful for safety. If we can identify which elements contribute to near-accidents, we can correct those elements before an accident occurs. Passive surveillance techniques require us to wait until after an accident occurs to identify it.

Direct Measurement/Observation

The most common, and in many ways the most useful, safety-related method is direct measurement and observation. Although many safety hazards result from subtle combinations of workplace elements, a great number of safety hazards are easy to identify and eliminate. We have a large and ever-expanding base of data related to unsafe actions, conditions, and designs.

A major frustration of safety professionals is that the same types of accidents happen over and over, even though we know what causes these accidents and how to prevent them. By going into the workplace and making fairly simple measurements and observations, we can identify and eliminate conditions known to cause accidents and injuries.

While the concepts of direct measurement and observation are simple, actually going into the workplace and performing these tasks can be daunting. As with other safety-related techniques, there must be some framework to organize the effort. One way to structure such measurements is with audit checklists similar to those described in Chapter 2. (Also see Table 2-7). Such checklists can organize your measurement efforts and provide a screen that prevents you from inadvertently omitting important measurements.

Direct observation can be performed either at the workplace or remotely, for example with videotape. In either case, analyzing the dynamic movements of workers requires a level of expertise and experience likely to be found only among professional human factors practitioners. Although non-professionals are certainly capable of identifying unsafe work practices and movements, so many variables can affect whether certain movements are safe or unsafe that it is best to enlist the help of a professional before you make any final judgment.

Job Hazard Analysis

Job Hazard Analysis (JHA) is the most fundamental technique associated with identifying and mitigating workplace hazards. JHA isn't just one technique, but a category of methods used, first, to identify, then, to evaluate, and, finally, to eliminate or minimize safety hazards. The identification phase of JHA usually involves a records analysis technique, such as surveillance; a reporting method, such as the Critical Incident Technique; or both. JHA sometimes uses an observation technique, such as video analysis. Regardless of the methods, its intent is to identify actual or potential safety hazards for later analysis.

After hazards are identified, JHA uses one of a number of evaluation methods to assess the safety risk of each potential hazard. These methods can range from analyzing worker motions using videotape to directly measuring weights, angles, temperatures, etc. The NIOSH lifting formula is a common evaluation tool for lifting hazards. Since very few entirely new hazards appear suddenly in the workplace, once a hazard is identified and evaluated, there are usually several existing strategies to eliminate the hazard or to minimize its effects. Risk control strategies include eliminating the source of the risk, building physical barriers between the hazard and the workers, and establishing different qualifications for those who perform the hazardous task.

NIOSH Lifting Formula

One of the most common hazardous tasks industrial workers undertake is lifting. Back injuries traditionally constitute the single largest category of work-related injuries, both in terms of numbers of occurrences and cost. Various studies over the past 20 or so years have identified the factors that contribute most to the high rate of back injuries.

The National Institute of Occupational Safety and Health has periodically assembled the relevant research findings regarding back injuries. In turn, NIOSH has distilled this empirical information into a mathematical equation that establishes a "safe" envelope for lifting tasks. This equation, shown later in the chapter in Figure 3-5, is known as the "lifting formula." The latest version of the NIOSH Lifting Formula was devised in 1991.[18]

Surveillance

As noted in the CONCEPTS section, *surveillance* refers to more than one technique. This concept is recognized in the FARs (Part 121.373) insofar as it pertains to the effectiveness of a certificate holder's maintenance program. That is, aviation maintenance organizations are required to monitor their repairs and inspections to ensure that they are done properly. This is conceptually similar to surveillance related to workplace safety. However, the emphasis in the FARs is on the airworthiness of aircraft, while this section of the *Guide* is concerned with the health and safety of aviation maintenance workers.

The most common type of surveillance, termed *passive surveillance*, involves monitoring and analyzing accident and injury records to identify patterns of recurring incidents. A passive surveillance analysis might identify a "cluster" of forklift accidents in a particular department or workshop. Passive surveillance uses all types of existing records, including medical, insurance, OSHA, production logs, etc.

Passive surveillance programs must consider and respect individual worker's privacy. Since these programs often access employees' private medical and insurance records, employers must be sensitive about the opportunity for abuse of individual privacy. One of the common abuses of Employee Assistance Programs is the use of employees' medical and psychological treatment records. Chapter 12 discusses these types of abuses in detail.

After passive surveillance identifies a potential safety hazard or a cluster of accidents, investigators take an active role in trying to verify the hazard and learn its causes and solutions. This is known as *active surveillance*, although its methods are akin to direct observation, interviews, critical incident reporting, etc.

It is unusual, although not unheard of, for individual organizations to have a formal surveillance program. Such efforts are usually part of an ongoing monitoring or loss prevention program conducted by a company's insurance carrier.

READER TASKS

Safety is an overriding consideration in the human factors domain. Regardless of any other characteristic of a product or system, it must not jeopardize the safety of its users. Obviously, some products are inherently dangerous, such as an explosive substance like dynamite. While this example makes the concept of inherent danger plain to most people, it is also inherently misleading. Many more people are injured in common workplace accidents each year than are injured working with explosives. The workplace is terribly dangerous, according to all injury statistics.[19]

In addition to being the cornerstone of human factors practice, safety is fraught with a number of practical issues that make it very complex. Each workplace has unique attributes that argue against general solutions to all safety problems. Also, certain workplace variables-such as training, experience, and protective clothing-render some hazardous tasks much less risky in some industrial settings than in others.

For these reasons, we are hesitant to recommend that readers of this *Guide* undertake *any* workplace-safety-related task without the benefit of professional expertise. Obviously, certain workplace-safety-related tasks can be done by non-professionals with a high confidence for success. However, for the tasks described below, we recommend that you involve an experienced human factors professional with both formal training and practical experience in industrial safety.

Developing a Safety Program

We recommended earlier in this chapter that every aviation maintenance organization have a formal safety program. Without such a formal program, there is no locus for safety-related activities. A formal safety program provides a tangible indication that management considers workplace safety important enough to expend the time, energy, and money required to maintain the program. Finally, participating in a formal safety program sensitizes workers to safety issues and provides relevant, factual information related to those issues.

Most aviation maintenance organizations are likely to already have a formal workplace safety program in place. It is rare for an industrial organization carrying Workers' Compensation insurance to be without a safety program. We include this task for the sake of completeness. Also, the general process that is used to set up a safety program initially includes activities that can be used to evaluate an existing program.

As noted in the introductory comments to this section, we strongly recommend that readers solicit and retain professional help when setting up their safety programs. Formal training and experience are essential for this first step in ensuring workplace safety. A properly-designed and -implemented safety program can provide the basis for an efficient and safe workplace. Conversely, a poorly designed safety program only wastes time and money, possibly increasing the risk of safety problems.

Evaluating an Existing Safety Program

As noted, most aviation maintenance organizations already participate in some type of formal workplace safety program. The operative reader task in these organizations is to assess the existing safety program's effectiveness. Any well-designed workplace safety program includes a built-in assessment function. Even the most conscientious safety program is subject to changes brought about by new materials, altered work schedules, new tools and test equipment, and changes in the mix of workers' skills and experience. Periodically evaluating the workplace safety program ensures that it evolves to meet changes in the work environment.

A safety program evaluation can take many forms. In the GUIDELINES section, we recommend that readers take a quantitative approach to analyzing the performance of their programs and provide a number of measures that can quantify the existing workplace safety program's outcome, i.e., product. These indicators are commonly used to determine whether a workplace safety program is generally doing what it is supposed to be doing. As with all product measures, these look only at the program's results, not at the processes causing those results. Because they look only at outcomes, these measures can mask both good and bad processes.

Evaluating Potential Safety Hazards

Much of the work in any safety program involves identifying and evaluating potential workplace hazards. While many hazards can be avoided through the use of good design practices, certain hazards are present because of often subtle combinations of workplace elements. It is almost always cheaper, and certainly more humane, to avoid risks than to mitigate their effects after someone is injured or property is damaged. However, we can't take steps to eliminate hazards until we know they are present. Thus, hazard identification and elimination is a primary function of any workplace safety program.

There are several approaches to evaluating potential safety hazards. Hazard identification techniques are usually lumped together as Job Safety Analysis (JSA) or Job Hazard Analysis (JHA). In many cases, JHA is part of an insurance carrier's loss prevention program. These types of programs generally look at accident statistics to identify the source(s) of actual injuries or equipment damage.

Readers should note well that these types of loss prevention programs are designed to prevent the insurance company's losses; looking at accident statistics is not a proactive technique. Of course, preventing these losses also benefits the maintenance organization, but the focus is on accidents that already have occurred. A better approach is to analyze tasks and the general workplace to identify safety hazards before they cause accidents.

Minimizing Safety Risks

There are methods to minimize risks associated with each category of workplace safety issues. Some methods deal directly with a recognized risk factor, e.g., reducing noise created by a riveting operation. Others control the consequences of an uncontrollable or residual risk factor, such as a hurricane. Still others attempt to create a psycho-social environment encouraging individual workers to stay alert for new, unforeseen risks such as those that might be follow the introduction a new piece of equipment.

The following section contains discussions and recommendations related to each reader task listed above and for each category of safety issues described earlier in the chapter.

GUIDELINES

In other chapters, we provide guidelines for those tasks that readers can undertake either by themselves or with some professional human factors assistance. In this chapter, **all** the tasks we've described require professional help. Even though expert help is required for these tasks, it is beneficial for readers to understand the bases for safety-related actions. In the following subsections, we provide enough information to allow readers actively to participate in various tasks related to their workplace safety programs.

Developing a Safety Program

We've noted above that readers should not attempt to develop a workplace safety program without professional help. Having made that point, we should also note that the likelihood of developing an effective program is dependent on the degree of management and worker involvement throughout the maintenance organization. Developing a safety program is no different in concept than developing any other type of participatory work program. A good analogy is developing a Total Quality Program. Quality programs developed with full management and worker participation, i.e., "buy in," are acknowledged to be more effective than programs developed entirely by outside consultants.[20] Top-down design is essentially a stepwise procedure in which general program elements are identified before more detailed elements. Figure 3-1 shows the overall process that should be followed when developing a workplace safety program.[21] As with any system or product, the process shown in Figure 3-1 contains elements of analysis, design, implementation, and evaluation. Note that the output of certain elements feeds forward or backward into other elements.

Understanding elements in the development process helps managers and technicians put the professional advice they receive into perspective.

The best guidance we can provide regarding developing a workplace safety program is that you should avoid two extremes. You should not try to develop a program entirely on your own, without any professional expertise; at the same time, you should not relinquish program development entirely to outside consultants. While you recognize that certain specialized knowledge and experience is required to develop an effective program, you should retain overall responsibility for your program and participate in its development. After the consultants go home, you have to live with the program every day.

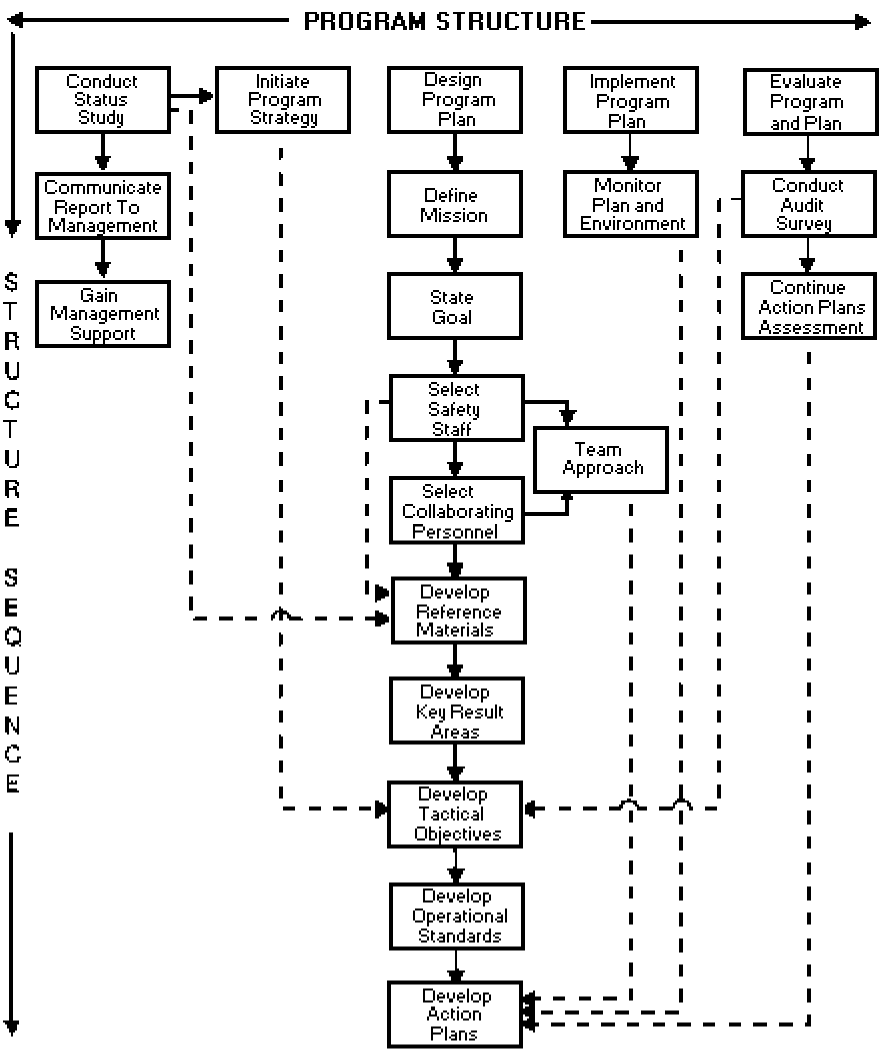


Figure 3-1. Overall process for developing a workplace safety program. (Weber, 1992)

Evaluating an Existing Safety Program

Chapter 1 of this *Guide* contains several checklists related to specific areas of workplace safety. The following four indexes provide information about the overall effectiveness of an existing safety program.[22] An effective program demonstrates a decline in any or all of these measures. It will also compare well with comparable measures from other organizations in the same industry group.

Disabling Injury Index (DII)

The DII combines frequency and severity measures into a single index. The Frequency Rate and

Severity Rate are defined below.

DII = Frequency Rate x Severity Rate

Frequency Rate (FR)

The FR represents the number of events (accidents or illnesses) per 100 employees in a given year. It is based on the ANSI Z 16.1 (1967) formula,[23] which predates the formation of OSHA

$$FR = \frac{\text{Number of events} \times 1{,}000{,}000}{\text{Total number of hours worked}}$$

Incident Rate (IR)

The IR is based on a formula OSHA developed to allow comparison with other organizations.[24]

$$IR = \frac{\text{Number of events} \times 200{,}000}{\text{Total number of hours worked}}$$

Severity Rate (SR)

The SR tracks the number of lost days associated with a particular type of event. This calculation can help determine if a certain type of problem, such as cumulative trauma disorders (CTDs), is responding to intervention, even if there is an increase in the number (frequency) of cases. It is not unusual for there to be an increased number of people reporting CTD symptoms following training on the topic. If the training and other solutions are successful, there will be fewer days lost for each new case.

$$SR = \frac{\text{Total of days lost} \times 1{,}000{,}000}{\text{Total number of hours worked}}$$

Other possible measures of severity include the following:

- Average number of days lost per employee per year
- Average Workers' Compensation costs paid per employee per year
- Total days lost for each type of disorder or injury
- Total Workers' Compensation costs paid for each type of disorder or injury.

Evaluating Potential Safety Hazards

It is difficult to consider workplace safety as a single issue. There are so many workplace elements that can be the source of safety hazards that one is quickly overwhelmed by a glance at the big picture. It is much more effective to divide the workplace into small topical areas that each can be examined for potential hazards. Table 3-2 lists six categories of workplace safety issues. These topical categories are useful subsets for hazard evaluation.

Just as it is difficult to view workplace safety as a single issue, it is inefficient to use a single technique to identify and evaluate safety hazards. While the process of hazard evaluation is collectively known as Job Hazard Analysis (JHA), it is really a number of separate techniques. A general rule that applies to safety, as well as other workplace topics, is that *the probability of finding something increases in direct proportion to the number of ways one looks for it*. An addendum to this rule is that the probability of finding something also increases with the number of times one looks for it. The most effective JHA (1) combines a variety of safety analysis methods to look for safety hazards and (2) repeats the analysis regularly.

We recommend that a workplace safety program include a function to identify and evaluate potential safety hazards. This function should be built around a JHA process that uses at least the following methods:

- *Surveillance* - Accident and injury statistics should be routinely reviewed and analyzed to identify trends and the causes or loci of various types of injuries and equipment damage.

- *Direct observation and measurement* -Safety committees composed of workers, management, and, occasionally, professional consultants should periodically observe maintenance operations to identify unsafe equipment or practices.

- *Analytical evaluation* - Maintenance tasks that are amenable to analytical evaluation, e.g., manual lifting, should periodically be subjected to the appropriate calculations. For manual lifting, the NIOSH Lifting Equation is an appropriate analytical tool.

- *Critical incident reporting* - A mechanism should be put into place to allow workers anonymously to report unsafe equipment or activities that resulted, or nearly resulted, in injury or equipment damage.

Effective workplace safety programs need to have a focus within the maintenance organization. This focus is traditionally provided by a safety committee composed of managers, workers, and, if necessary, professional consultants. Committee membership usually rotates among various members of the organization. If potential safety hazards are identified, but the safety committee lacks the knowledge or experience to fully evaluate their risk, then an outside safety consultant should be retained to help make a risk determination.

Minimizing Safety Risks

The overall goal of any safety program is to prevent personal injuries and equipment damage. It makes moral and economic sense to avoid problems, rather than to deal with their consequences. The following guidelines are aimed at reducing the risk of safety problems by taking proactive steps to minimize workplace risks.

Individual Issues

As noted earlier, there are a number of safety issues related mainly to individual workers. We address the following individual safety issues:

- Behavior/Motivation
- Clothing/Personal Protective Equipment
- Fitness/Wellness
- Training/Skill Level
- Alienation
- Violence.

Behavior/Motivation. There are several behavioral theories addressing why workers injure themselves or otherwise fail as a system component. Workers may not care about the consequences; they could misperceive the risks or the consequences; or they might intentionally sabotage the system. All of these theories agree about the positive contribution of the following:

- individual participation in goal setting
- adequate and appropriate feedback about workers' actions
- an understanding of cause and effect relationships in the workplace
- sufficient training in recognizing and managing the potential hazards on the job.

Clothing/Personal Protective Equipment. People usually work best when unencumbered by heavy clothing or personal protective equipment (PPE) such as gloves or respirators. It is critical that workers have appropriate clothing and PPE, but improperly fitting PPE can create a new hazard. Proper training in the correct way to wear and use PPE is also important. PPE can protect workers' eyes, ears, feet, hands, head, and respiratory processes. An example of eye and respiratory PPE is shown in Figure 3-2. A more radical example of PPE is shown in Figure 3-3.

Figure 3-2. Example of eye and respiratory PPE. (Courtesy of Delta Air Lines)

Figure 3-3. Complete suit of PPE. (Courtesy of Northwest Airlines)

Unfortunately, no PPE has been proven effective for Cumulative Trauma Disorders, including most lower back problems. The only exception is hearing protection such as ear plugs and ear muffs. Wrist splints or braces are considered therapeutic devices for treatment, not for prevention, and should be used under the super-vision of a medical professional. There is no compelling evidence of reduced risk of back injury while wearing back belts.[25] In fact, wearers may be at greater risk than non-wearers.

Fitness/Wellness. Recent evidence shows a high return on investment for individual wellness programs.[26] These financial benefits should increase the number of organizations with comprehensive wellness programs. A wellness program should address a specific organization's needs, not simply copy what worked at another company. You should use employee screening to identify your organization's specific needs.

There is increasing evidence that a healthy person can remain vigorous and relatively pain free until the end of his or her life. It is important to provide employees with information about non-work activities that affect their health and safety while also respecting individuals' privacy.

Chronic conditions or disease processes may increase the risk of workers developing work-related symptoms. For example, circulatory problems such as those from diabetes may lead to symptoms of Raynaud's Syndrome or Vibratory-Induced White Finger Syndrome. Though the primary cause of such diseases is not work-related, it would be prudent to modify the diabetic person's work to reduce the risk that he or she may develop symptoms.

Training/Skill level. The FAA specifies the training necessary for AMT certification.[27] When training is coupled with job-specific safety information and ongoing feedback about performance, most workers will experience few safety problems during their careers. Carefully considering the implications of changing a work procedure or installing different equipment, for instance, further decreases the probability of safety problems.

Alienation. More and more people report feeling estranged from their work environment. The breakdown of previously close and supportive relationships between an individual and his or her organization can create dangerous situations such as sabotage or negligence. It is probably true that no one is completely integrated into an organization. We all have other hobbies and activities, which are sometimes subjectively more important than our jobs.

Alienation is implicated in stress complaints, fatigue reports, poor quality, and reduced productivity. Organizations may reduce alienation with an active suggestion system, an open-door policy, a formal grievance and appeals process, and other behavior motivation suggestions such as those we listed previously in this chapter.

Violence. There is a recent trend toward increased workplace violence. A recent report shows that personal assault is the second most frequent cause of occupational death in the United States.[19] Though this problem is not widely recognized in aviation maintenance, violence is associated with increased employee turnover and layoffs, facility closings, increased job demands and other trends that are becoming increasingly common in the aviation industry.

Organizations can participate in Employee Assistance Programs to provide counseling and other services to reduce workers' unnecessary stress. Employees also benefit from conflict resolution training to help them deal with personal and interpersonal problems. Finally, an Employee Assistance Program should have an emergency action plan in effect to deal with hostage, terrorist, and other potentially violent situations (see Chapter 12).

Task Issues

Some safety hazards are the result of the inherent nature of certain maintenance tasks. In this section, we address the following task-related issues:

- Monotony/Variety
- Postures
- Cumulative Trauma Disorders
- Lifting/Manual Material Handling.

Monotony/Variety. Everyone has some degree of the need for variety. Some people prefer a high percentage of routine tasks in their daily routine. Others need more varied activities to feel motivated and stimulated. Neither need is more correct or more natural, and most of us prefer a mix of routine and variety. It is more effective to accommodate an individual's needs and style than to attempt to change the individual's basic personality. For certain tasks such as repetitive inspection it is important to maintain at least some minimal level of stimulation to prevent drowsiness or inattention.

Posture. Recently, organizations have given much attention to the issue of working postures. It is very risky to work at the extremes of our reach, especially if we are applying force. It is also risky to work in awkward or unbalanced postures. Figure 3-4 shows neutral postures for standing and sitting work positions. Sitting or standing still for long periods is troublesome, as is any posture that reduces local blood flow in the muscles. Training in proper postures is important, but not sufficient. It is more effective to be alert for opportunities to redesign the workplace and work tasks to eliminate the need for risky postures.

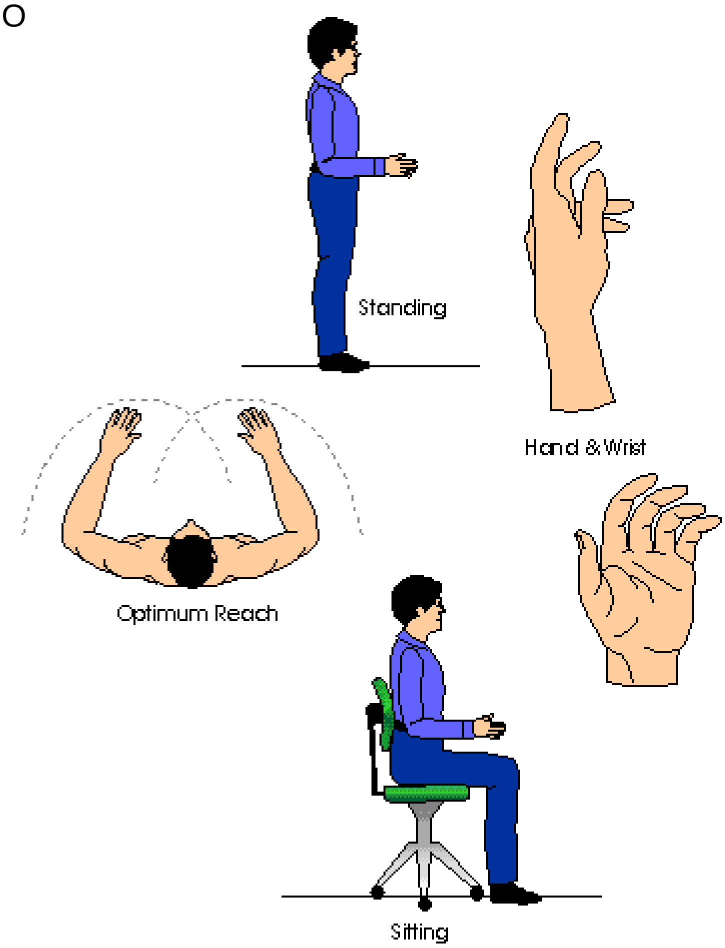


Figure 3-4. Neutral working postures.

Cumulative Trauma Disorders. CTDs arise from repeated stress, usually to only one or two joints. CTDs do not produce immediate symptoms, but long-term problems. Carpal Tunnel Syndrome, de Quervain's Syndrome, tendonitis, and ganglionic cysts are examples of CTDs resulting from repeated stress. Many lower back injuries, as well as noise-induced hearing loss, are common examples of the cumulative effects of everyday activities.

Much of the recent increase in Workers' Compensation and Group Medical Insurance costs arise from CTD claims. The increased incidence of these problems probably results from the specialized, repetitive nature of many modern jobs; from better record keeping practices; from more consistent diagnoses; and from an increased awareness of CTDs in the general population and among professionals.

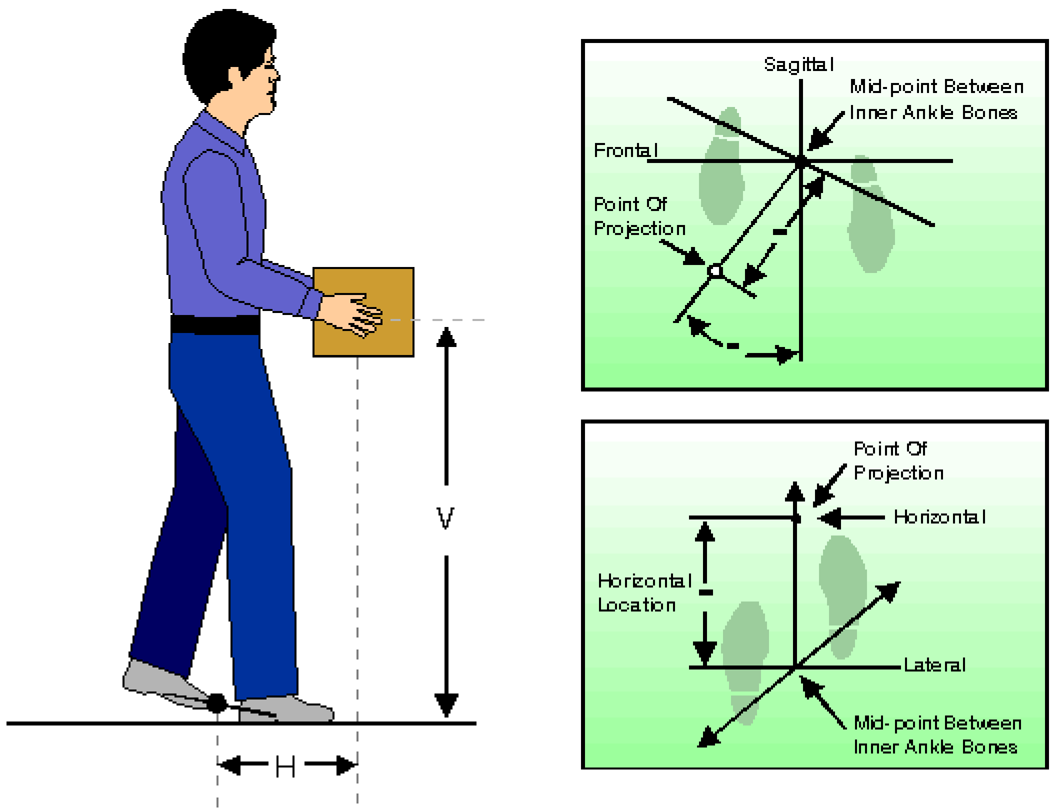
The most successful CTD prevention programs combine actions OSHA recommended in its first ergonomics guide.[28] These actions include the following:

- Effective management commitment
- Work and workplace analysis to discover possible hazards
- Modifications to the work and workplace to reduce hazards and to manage any residual consequences
- Training for all affected employees in the causes, symptoms, process, treatment and (most importantly) the prevention of CTDs.

Lifting/Manual Material Handling. The new National Institute for Occupational Safety and Health (NIOSH) guidelines for lifting activities[21] reflect new findings on lifting limits. They also provide methods for evaluating asymmetrical lifting tasks i.e., when the object is not directly in front of the body, and the effects of various handles (coupling).

The physical components of the NIOSH lifting formula are shown in Figure 3-5. Its applicability over a greater range of lift duration and frequencies than the 1981 version makes the new guide useful in more real-world situations. Since the maximum recommended weight of lift is now only 51 pounds, and, because there are several other factors to consider, actual recommended weights tend to be less now than with the previous formula.

The Frequency Multiplier (FM) factor in the lifting equation is given in Table 3-3 for a range of work duration and beginning lifting heights.



Recommended Weight Limit (RWL) = LC x HM x VM x DM x AM x FM x CM

Where:

		Metric (cm)	U.S. Customary (inches)	Description
LC = Load Constant	=	23 kg	51 lb	Maximum Weight
HM = Horizontal Multiplier	=	(25/H)	(10/H)	H = Horizontal Location
VM = Vertical Multiplier	=	1-(.003|V-75|)	1-(.0075|V-30|)	V = Handgrip Height
DM = Distance Multiplier	=	.82+(4.5/D)	.82+(1.8/D)	D = Vertical Distance of Lift
AM = Assymmetry Multiplier	=	1-(.0032A)	1-(.0032A)	A = Angle of Assymmetry
FM = Frequency Multiplier	=	(see Table 3-3)	(see Table 3-3)	
CM = Coupling Multiplier	=	(see below)	(see below)	

Coupling Multipliers (CM) when:

V <30 in. (76cm)	V ≥30 in. (76cm)	and the coupling type rating is:
1.0	1.0	Good = optimal container and handgrips/handles
.95	1.0	Fair = non-optimal container **or** handgrips/handles
.90	.95	Poor = non-optimal container **and** handgrips/handles

Figure 3-5. NIOSH lifting formula - 1991.

Table 3-3. Frequency Multiplier Table (FM).

Frequency‡	Work Duration					
Lifts/min	£ 1 Hour		>1 but £ 2 Hours		>2 but £ 8 Hours	
(F)	V† < 30	V ³ 30	V < 30	V ³ 30	V < 30	V ³ 30
£ 0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

† Values of V are in inches.

‡ For lifting less frequently than once per 5 minutes, set F = .2 lifts/minute.

The 1991 formula provides lifting guidance only for two-handed lifting activities. It is not applicable to, and might under- or over-estimate the recommended weight in other situations like the following:

- When non-lifting situations, such as walking up stairs, are a large part of the job being evaluated
- If there are unusual working conditions, such as unexpectedly heavy loads or unfavorable environments
- When lifting in unusual postures, such as seated, kneeling, or constrained

- When lifting unusually hot, cold, or contaminated objects
- Wheel barrow or shoveling operations
- High-speed, jerky lifts lasting less than 2-4 seconds
- While standing on a floor with a coefficient of static friction less than 0.4 (approximately the same as a clean, dry leather work shoe on a smooth, dry floor)
- When lifting and lowering are different as when a person must lift an object, but then drops it rather than having to lower it.

Figure 3-6 provides an example of how the NIOSH Lifting Equation can be used in the aviation maintenance environment. In this example, a technician working an 8-hour shift must occasionally (3 or 4 times per shift) lift a cardboard box from a wooden pallet resting on the floor to a workbench top that is 34 inches above the floor. The box contains a subassembly and is smooth, i.e., has no handles. The box and subassembly weigh a total of 38 pounds. The relative positions of the pallet and workbench require the technician to walk to the pallet and face the cardboard box while lifting it to waist level. The technician then carries the box to the workbench and places it on the top of the bench.

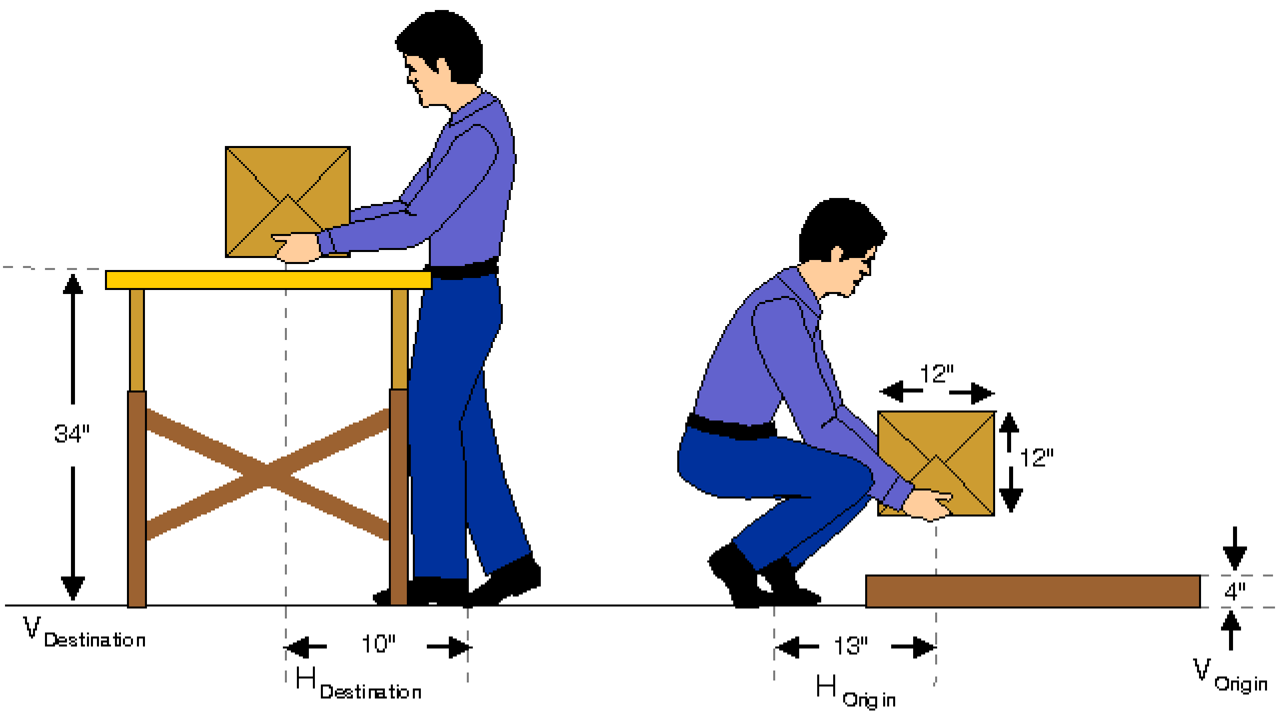


Figure 3-6. Example of a lifting task.

The basic question we're trying to answer is whether the box weighs too much for the technician to lift it safely. For simplicity, we'll assume that prior to lifting the box from the pallet, the technician slides it to the edge, avoiding a situation in which he or she has to lean over the edge of the pallet.

Using the Lifting Analysis Worksheet in Appendix A Figure 3-7 and the information in Figure 3-5 and Table 3-3, we will determine whether this is a safe lifting task. The Lifting Analysis Worksheet is adapted from the NIOSH Application Guide[29] and is included as Appendix A of this chapter. After filling in the descriptive information in the top section of the Worksheet, we should enter the task variables in the section marked Step 1.

The average and maximum object weight is the same, i.e., 38 pounds. Vertical hand locations are the top surface of the pallet and the top surface of the workbench, since the technician must lift the box from its bottom surface. The vertical distance (D) is simply the difference between the origin and the destination vertical hand positions. This number is always positive, regardless of the relationship of the origin and destination vertical hand positions.

Because we've said that the technician is facing the load at both the origin and the destination, there is no asymmetry to the lift. There are only a few of these lifts per shift; therefore, the frequency (the left-hand column in Table 3-3) should be taken as "≤ .2". Likewise, the work duration of the task should be taken as "≤ 1 hour". Finally, the object coupling, listed in Figure 3-5, should be taken as "Fair" since the container is not particularly awkward, but has no hand grips.

Lifting Analysis Worksheet

Department: Hydraulic Shop
Job Title: Seal Technician
Analyst: JTB
Date: 1/23/95

Job Description: Install manifold subassembly

Step 1. Measure and record task variables.

Object Weight (lbs)		Hand Location (inches)				Vertical Distance (inches)	Asymmetry Angle (degrees)		Lifting Frequency (lifts/minute)	Duration (hours)	Object Coupling
		Origin		Destination			Origin	Destination			
L avg	L max	H	V	H	V	D	A	A	F		C
38	38	13	4	10	34	30	0	0	≤ .2	≤ 1	Fair

Step 2. Determine the multipliers and compute the RWL's.

RWL = LC x HM x VM x DM x AM x FM x CM

Origin -- RWL = 51 x .77 x .81 x .88 x 1.00 x 1.00 x .95 = 26.59 **pounds**

Destination -- RWL = 51 x 1.00 x .97 x .88 x 1.00 x 1.00 x 1.00 = 43.53 **pounds**

Step 3. Compute the Lifting Index (LI) for origin and destination.

Origin LI = $\frac{\text{Object Weight (L)}}{\text{RWL}} = \frac{38}{26.59} = 1.4$

Destination LI = $\frac{\text{Object Weight (L)}}{\text{RWL}} = \frac{38}{43.53} = 0.9$

Figure 3-7. Lifting Analysis Worksheet, example.

In Step 2 of the Worksheet, we can enter the factors in the Lifting Equation. Note that we calculate the Recommended Weight Limit (RWL) for both the lift's origin and its destination. Using the equations listed in Figure 3-5, we calculate the origin RWL as follows:

- LC is constant and equal to 51 pounds
- The origin "H" is listed in Figure 3-6 as 13". Therefore, HM is 10/13 = .77.
- The origin "V" is 4". Therefore, VM is 1-(.0075 |4-30|) = .81.
- The difference between the origin and destination vertical hand position is 34-4=30". Therefore, DM is .82+(1.8/30) = .88.
- There is no asymmetry, "A," so AM = 1.00.
- From Table 3-3, we take the factor at the intersection of F = ≤0.2 and Work Duration = ≤ 1 hour, which is FM = 1.00.
- From Figure 3-5, we take the Coupling Multiplier for V < 30" (since the vertical hand position at the origin of the lift is only 4") and the coupling type of "Fair". Thus CM = .95.

- Carrying through the calculation for the origin RWL, we find that it is 26.59 pounds, which can be rounded to 26.6 pounds.

A similar calculation for the destination RWL yields 43.5 pounds. Moving to Step 3 of the Worksheet, we now calculate the Lifting Index for both the origin and the destination. The Lifting Index is merely an indication of how heavy the actual load is compared to the RWL. From these simple calculations, using an object weight of 38 pounds, we see that the Lifting Indices are 1.4 and 0.9 for the origin and destination, respectively.

Since the origin Lifting Index is greater than 1, this part of the task is likely to be hazardous for most technicians. To remedy this, begin by looking at the *smallest* modifiers in the origin calculation. In our example, these would be the horizontal multiplier (HM = .77) and the vertical multiplier (VM = .81). If we can raise the load and move the technician closer, our origin Lifting Index will come down closer to 1. This can be done easily by placing the pallet on a lift table.

Everyone involved in lifting activities or supervising lifting activities needs to know the major risk factors associated with material handling injuries and how to quickly analyze the material handling activities. It is not necessary to undertake a complete lifting analysis using the NIOSH Lifting Equation until an evaluation shows a reason for concern.

Basically, any activity that can lead to possible overexertion is suspect. Personal issues such as inadequate strength, limited flexibility, reduced coordination, inappropriate mental state, or a history of musculoskeletal problems increase the risks associated with material handling. Handling an awkward or heavy object (especially if it weighs more than 50 pounds) may require excessive force. Environmental factors, including poor footing, annoying noise, whole body vibration (such as in a truck cab), or extreme heat, humidity, or cold temperatures, can also increase risk.

Other activities that can increase material handling risks are repeating the lifting activity more than 15 times per shift; lifting and holding; lifting and carrying; jerking the material; skipping breaks; performing the same activities throughout the shift; and lifting while bent, twisted, or squatted. It is also risky to lift from or to extremely low or high locations. To reduce the risk of injuries, workers should keep their hands close to the spine, between the knees and shoulders, and directly in front of the body while they handle materials.

Tool and Equipment Issues

Maintenance tasks generally require the use of tools, fixtures, and test and support equipment. This is certainly true of aviation maintenance. Certain components are routinely removed from aircraft and taken to a shop for maintenance. Other aviation maintenance tasks involve the airframe itself. In either case, the tools and equipment often present safety risks. The following tool and equipment issues are addressed in this section of the *Guide*:

- Work support systems
- Electronics and radiation
- Vibration
- Guarding
- Motorized vehicles
- Docks and chocks
- Workstation design
- Hand tool design.

Work support systems. A recent report by the FAA/AAM discussed the awkward, fatiguing positions required by some work stands; overhead work is especially troublesome.[30] The report also noted the inherent instability of "cherry pickers." A safety risk exists when outrigger supports are needed, but not used, on any mobile lift. Another problem is the difficulty of detailed visual inspections with the current work support systems. Finally, it is difficult and potentially unsafe for a worker to apply large torsion forces, such as when using a large wrench, while standing on many of the existing support structures. The support may move or tip over during such an activity. Hoffman included hangars, service vehicles (including trucks), service platforms (both mobile and stationary), maintenance docks, and ladders in his discussion of work support systems.[31]

These authors suggest reviewing accident data to detect incident patterns or unsafe equipment. Proposed human factors standards (such as Hoffman's[31]) would address stability requirements, anti-skid work surfaces, fall protection equipment, and emergency warning and escape attributes. Subpart F of CFR 1910 includes additional standards for powered platforms, manlifts, and vehicle-mounted work platforms.

Electronics and radiation. There has been a gradual increase in the number of avionics components and electronic testing equipment in aviation maintenance. With this increase comes some concern about electromagnetic radiation effects. Radar calibration, for instance, could be risky when the AMT does not follow proper procedures. Because modern equipment meets radiated energy guidelines, probably the most frequent risk is damage to the avionics and test equipment, not to people. Effective training in the best way to use equipment is critical. It is equally important to ensure, through proper maintenance and testing, that the equipment stays within radiation guidelines.

Vibration. Typically, segmental vibration of a part of the body (especially the hand and arm) is more troublesome than whole-body vibration. Various body parts have resonant frequencies when they vibrate in unison with a source in the range of 4-150 Hz. The range between 50-150 Hz is most troublesome for the hand and is associated with Vibratory-Induced White Finger Syndrome (VWF). Pneumatic tools can produce troublesome vibrations in this range and are implicated in the reduced local blood flow and pain of VWF. It is necessary to reduce these vibrations in amplitude, to change their dominant frequency to one higher or lower, to provide dampening material, and to limit workers' exposure time. Typical usage for pneumatic tools in aviation maintenance is shown in Figure 3-8.

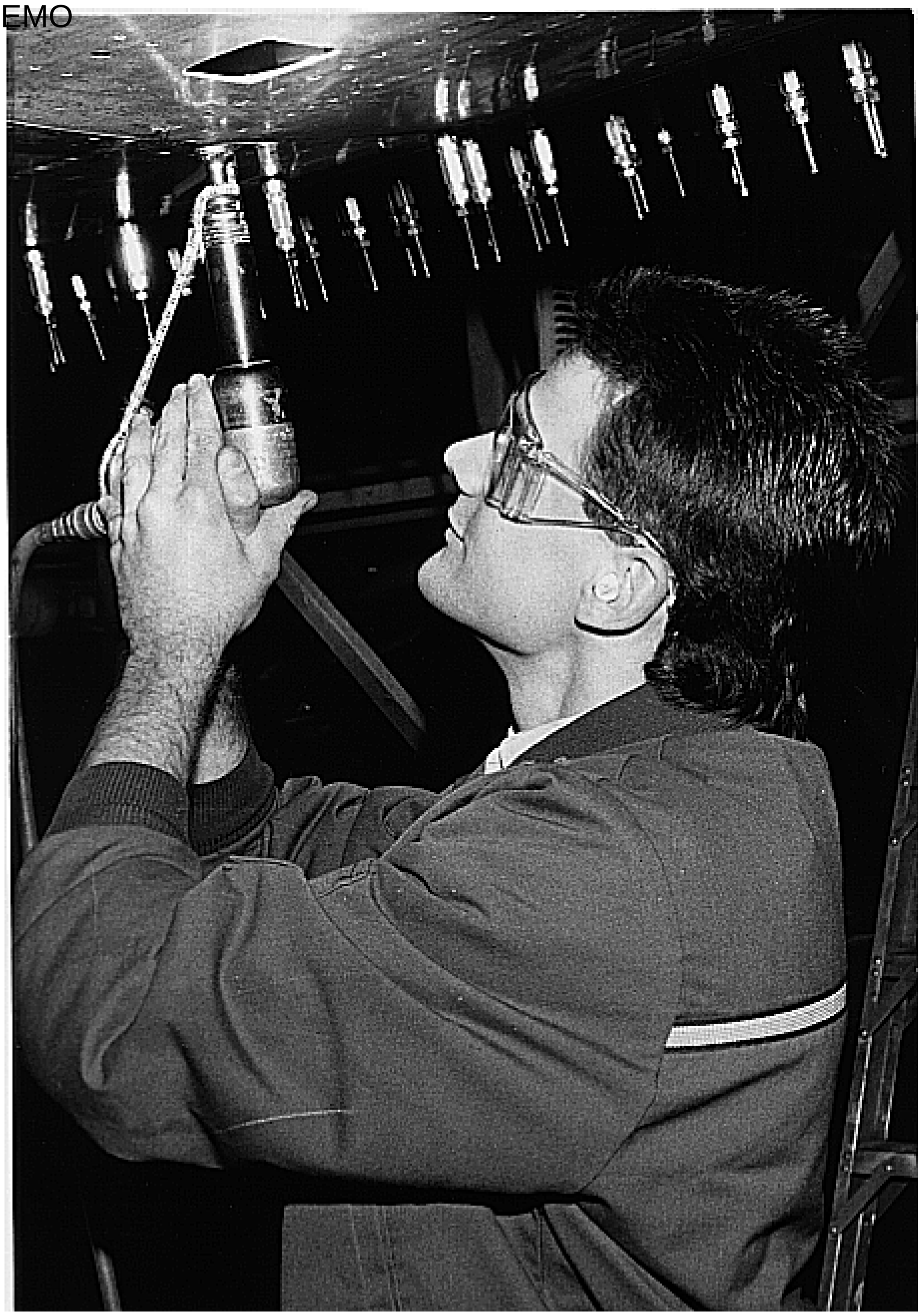


Figure 3-8. Usage of pneumatic tools in aviation maintenance. (Courtesy of Delta Air Lines)

Guarding and tool use. A safe environment ensures the separation of people from rotating or moving equipment. Subpart O of the CFR 1910 OSHA standards describes specific guarding situations and solutions. Progressive discipline is necessary whenever anyone attempts to defeat these guards, although such behavior may indicate inadequate equipment design. Guards are more likely to be removed or defeated if they interfere with workers' job activities.

Motorized vehicles. Motorized vehicles include a range of vehicles from powered hand trucks and fork lifts to automobiles and trucks used in maintenance. Using motorized vehicles is the most dangerous activity most people undertake during their working lives.

Subpart N of CFR 1910 includes guidelines for powered industrial trucks and other heavier vehicles. Basically, it is necessary to ensure that no one runs a vehicle into another person or damages another object. It is also important to prevent the operator from falling from the vehicle. Falls from motorized vehicles can directly cause operator injuries and loss of vehicle control. Falls can be prevented with harnesses or other operator restraints. Periodic planned maintenance of the vehicles and recurring training (at least annually) of the operators reduces risk. Progressive discipline and safety incentives may have short-term positive effects.

Docks and chocks. Most maintenance facilities have incoming materials docks for offloading trucks. Common unsafe situations include lifting hazards (such as dock plates), potential drive-aways (trucks leaving before unloading is finished), and disconnected trailers with no wheel chocks to prevent runaways.

The same lifting guidelines apply to the dock area as to other areas in the maintenance organization. Dock plates should be replaced with modern coupling devices, when possible. Dock latching devices secure the truck or trailer to the dock until the personnel unloading the vehicle are clear; they prevent drive-aways and runaway trailers. Inexpensive, lightweight wheel chocks provide considerable protection from runaway trailers anywhere on the parking areas.

Workstation design. When there is a mismatch between the person doing the work and the workstation he or she uses, both productivity and safety can suffer. Major workstation design principles relate to seating, work surface, reach profiles, available space, and work item organization. (See Chapter 6 for more details.)

Adjustable seating and work surfaces improve the match between the person and the workstation. It may be necessary to provide several sizes of workstation seating due to the variability of body sizes. Reach profiles refer to the work surface (bench top or work table) area the hands cover during normal working activities. Most of the work should occur in the area a person can reach with his or her elbows hanging relaxed at his or her sides.

It is permissible for workers occasionally to extend their elbows to reach something, but this action should be minimized. Do not require workers to reach with their shoulders and backs. Workers must have enough space to move around and to reach and see into areas necessary for their work activities. Train them to organize their work items to reduce reaching and holding. Provide them with holders, shelves, articulating arms, cutting jigs, and other fixtures to reduce reaching and holding further.

Hand tool design. The design of many hand tools has evolved over the past several years, as new users have modified tools to meet their needs. Such modifications do not ensure good tool design and does not guarantee that everyone can use the same tool. An ideal tool embodies the design elements listed below. Use these elements to evaluate hand tools you are considering using in your workplace:

- Keeping a straight wrist and relaxed elbow and shoulder during work
- Suitable surface characteristics, including durability; adequate friction; and protection from hazards, such as thermal or electrical energy
- Appropriate grip size for the person using the tool; this ranges from about 1-3 inches in diameter
- Comfortable hand grip area so that force is not concentrated on a small area of the palm or between the fingers
- Enough leverage to perform the task
- No frequent or constant one-finger pressing or trigger squeezing
- Minimized vibration
- Ambidextrous use, *i.e.*, for either hand
- Low shock and torque transmission to the person
- Appropriate weight, light enough to reduce fatigue, but heavy enough to be stable
- Spring loaded operation to reduce finger/thumb activity
- No pinch points or sharp edges that might injure the user

- Easy to use and maintain.

Facilities and Environment Issues

Productivity-related facility issues are discussed in Chapter 5. Many facility and environmental characteristics also present potential safety hazards. In this section, we discuss the following facility and environmental issues:

- Lighting
- Noise
- Temperature
- Air quality
- Housekeeping
- Ingress/Egress
- Walking and working surfaces
- Stairs and fixed ladders.

Lighting. Most human activities rely on visual feedback, as do most aviation maintenance tasks. There are two potential problems associated with lighting in the maintenance workplace: 1) too little light where it is needed and 2) glare.

Drury found an average of 51 foot-candles (ft-c) (550 lx) of light available in the nighttime maintenance facilities he examined.[32] He recommended a minimum of 75 ft-c (800 lx). Some very difficult, but critical, inspection situations may require a minimum of 95 ft-c (1000 lx) or special lighting, e.g., polarized or infrared. Individual light requirements may double with age. Whereas 50 ft-c (540 lx) may be sufficient for a 25-year-old worker, a 55-year-old may need 100 ft-c (1075 lx) to perform the same task.[33]

Glare is light that interferes with accomplishing a task; it may be direct (in the line of sight) or indirect (bouncing off the viewed object). The best way to deal with direct glare is to shield the light source from view or to move it out of the line of sight. Indirect glare may be reduced by shielding or filtering. It may also be possible to reduce glare by reducing the amount of light generated. However, it is usually most effective to move a viewed object (such as a computer display) so there is no glare.

Noise. An FAA Audit Team found acceptable noise levels of 70-75 dBA at the maintenance sites they visited.[32] However, they were concerned about occasional noise levels in excess of 110 dBA and suggested limiting exposure to these. Others have found a direct correlation between the average noise level present at a job and the job's accident rate.[34]

It is appropriate to reduce noise levels whenever practical because noise is a fatiguing stimulus, even at levels as low as 65 dBA. It is also reasonable to assume that any factor that can create increased muscle tenseness, as noise can, contributes to the possible development of Cumulative Trauma Disorders and circulatory problems. Noise effects are highly individual; some people are greatly bothered while others hardly notice. This relates directly to an individual's personality type and sense of personal control over the noise.[35]

Engineering noise control methods include the following:[36]

- Reducing noise at the source by adjusting reciprocating equipment or adding mufflers
- Interrupting the noise path with barriers
- Reducing reverberation with damping material or stiffening techniques
- Reduce structure-borne vibration with vibration mounts and lubrication.

Whenever an employee's exposure to noise exceeds guidelines, it is important and necessary to implement a hearing conservation program. The basic components of such a program include the following:[36]

- Noise exposure monitoring
- Engineering and administrative controls to reduce exposure
- Audiometric evaluation (a hearing test) to detect changes in individual hearing ability
- Proper use of hearing protection devices such as ear plugs or muffs
- Education, motivation, and discipline
- Record keeping
- Periodic program evaluation.

Temperature. Most aviation maintenance tasks take place in large hangars, frequently with open bay doors. Since it is difficult to precisely control the temperature in such a facility, it is important to understand the safety and performance effects of various temperatures. Table 3-4 summarizes the general effects of ambient temperature on performance (adapted from Woodson[37]).

Table 3-4. Human performance at various temperatures.

Temperature (F)	Performance Effect
90	Upper limit for performance
80	Maximum acceptable upper limit
75	Optimum with minimal clothing
70	Optimum for typical clothing and tasks
65	Optimum for winter clothing
60	Hand and finger dexterity begins to deteriorate
55	Hand dexterity reduced by 50%

The best methods of controlling heat-stress effects include the following:[38]

- Reduce the amount of heat produced and transmitted to the person through process modification and barriers
- Allow the worker to lose heat through convection and evaporation
- Do not force a worker to wear unnecessary clothing or equipment and keep his or her physical exertion level low
- Provide fans, air conditioning, or personal cooling garments, as appropriate
- Ensure that the individual is fit, suitable, and acclimatized to the heat
- Supply emergency treatment and sufficient rest time in a cooler environment.

Low temperatures can be as stressful and dangerous as high temperatures. The effects of cold can be more subtle and insidious than those of heat. Cold stress can usually be effectively handled by providing the following elements:

- Windbreaks
- Local heat sources
- Dry, windproof, layered clothing.

Air quality. Air quality is traditionally more of an industrial hygiene issue than a human factors issue. However, air quality can directly affect certain human performance levels. It is possible for some airborne toxins to increase the risk of Cumulative Trauma Disorders by impairing peripheral blood flow (to the hands, for instance). Increased carbon monoxide levels can reduce mental alertness, increasing the risk of an accident or error. It is necessary to keep oxygen levels around 20% to ensure optimum performance. An efficient heating ventilation and air conditioning system is critical for maintaining appropriate humidity, air content, and air movement levels.

Housekeeping. Accidents correlate to workplace cleanliness and order. A clean and well-ordered workplace demonstrates a professional attitude toward the work being performed. It also reduces the number of workplace hazards present. It is impossible to trip over something that is not left laying around. Tools and equipment stored correctly last longer, are easier to find, and work better. Clean walls, ceilings, and floors distribute available light more evenly and efficiently, with less glare. If everyone cleans up spills as soon as possible, there is less chance of material contamination, slips and falls, and burns of the eyes or skin.

Ingress/Egress. OSHA and most local fire-control authorities require at least *two* means of accessing a workspace. This access must be along unobstructed corridors and through doors wide enough to accommodate emergency traffic. With the advent of the Americans with Disabilities Act (ADA),[8] it is important to plan for quick egress by people in wheelchairs, or otherwise encumbered or impaired.

Make sure that doors located along escape routes open with the flow of escaping traffic, so they will not block the traffic flow during the initial opening. Do not lock these doors without providing an emergency disconnect. There must be adequate lighting to aid escape, and the escape door must usually be marked with a lighted sign so it can be located in dim ambient light. It is smart to label non-exits, especially if they might trap people during an emergency. Your emergency plan should include escape routes from all work positions.

Walking and working surfaces. People need good footing to prevent them from slipping and falling, especially if they are carrying, pushing, or pulling an object. Usually, this means a minimum coefficient of static friction of approximately 0.5 between the person's shoe soles and the floor. It is also important to protect people from other hazards, such as electrical shock, electrostatic discharge, chemical spills, and holes and irregularities in or on the surface.

Walking surfaces should be clean; appropriately sanitary; dry; and free of loose items or tripping hazards, such as protruding nails, splinters, holes greater than one inch in diameter, or loose boards. Floor load ratings must exceed the weight of the loads imposed on the floors. This is tricky because a single file cabinet often can exceed a typical load rating.

Covers and guard rails protect people from falling into holes, off balconies, or into stair wells. Guard rails should be able to withstand 200 pounds of force applied in any direction to the top rail. Toeboards four inches high, starting within 1/4" of the floor on an overhead level help protect people below from falling objects.

Fixed ladders require a minimum rung diameter of 0.75" (metal) or 1.125" (wood) with a maximum distance between rungs of 12". Uniform spacing between rungs reduces the risk of workers falling from the ladder. Keep the foot from sliding off the end of a rung. Rungs must be at least 16" long and must be at least 7" from the wall to provide room for feet and hands. People need a minimum of 36" of clearance between the ladder and objects behind their back, as well as from side to side, to allow them enough body room to climb the ladder. Provide a landing for rest every 20 feet of vertical climb. In some situations, you may need special protective cages, hatch covers, or wells.

Stairs and fixed ladders. Stairs designed for regular traffic should incline between 30 and 50 degrees. They should have 6-9 inch treads, with a rise of between 7 and 12 inches per tread. Slip resistance is important; the slip-resistant technique that is best for a particular location depends on the type of contaminants - sand, oil, or ice, for example - found on adjacent walking surfaces. Stairs and landings are usually a minimum of 30 inches wide with a railing on the open side(s) or right side, when one is descending, of an enclosed stairway. Provide a minimum of 7 feet of clearance between any tread or landing and overhead objects.

Materials Issues

Materials used in the aviation maintenance workplace include common components, raw metal and composite materials, and hazardous chemicals. Most aviation maintenance facilities need a written hazardous chemicals/materials program including the following elements:

- Hazard assessment/evaluation to determine which hazardous materials are present at the workplace
- Proper container labeling to identify materials and to warn anyone shipping, storing, or using them
- Material Safety Data Sheets (MSDS) on all hazardous materials
- Employee training and information programs and systems
- Emergency procedures, including prior notification and coordination with local authorities, to deal with leaks, spills, or other undesirable events.

Refer to 29 CFR 1910.1200 (Hazard Communication) for additional information on evaluating chemical hazards and informing everyone who may be affected. OSHA regulations, 29 CFR 1910 - Subparts 102-106, also give specific use and storage guidelines for acetylene, hydrogen, oxygen, nitrous oxide, and flammable or combustible liquids.

There are a number of safety issues related to materials used in the aviation maintenance workplace. In this section, we describe the safety implications of the following materials-related issues:

- Composites
- Degreasers and solvents
- Deicing fluids
- Fuels and flammables
- Storage.

Composites. There is increased use of composite materials like graphite and fiberglass in the aviation industry. Maintenance technicians and repairmen must understand hazards associated with these materials and with methods for managing any undesirable effects.[39] As much as 20% of a workforce can develop dermatitis from working with plastic resins. Phenolformaldehyde materials can irritate the skin, eyes, and nose. It is necessary to identify such hazards and then inform everyone exposed to them. Good management techniques[39] for working with composites include the following:

- No smoking or eating in the workplace
- Using appropriate skin and respiratory protection
- Providing good lighting and HVAC
- Placing hand and eye washing stations in convenient locations
- Providing limited test runs of new materials
- Communicating any problems to all affected
- Developing a team of "first responders" to address immediate problems or concerns.

Degreasers, solvents, and chemical strippers. The most common problems associated with degreasing and solvent compounds relate to how they are stored and disposed. Degreasing or solvent baths are dangerous to people and to equipment when they are left open; the best designs include self-closing covers. Many baths have unsuitable (often temporary), unstable bases or stands. Replace these with appropriate stands. Dispose of these compounds correctly to reduce environmental impact and to protect people from accidental exposure.

The aviation industry is wisely finding replacements for many previously used troublesome chemicals. Workley[40] mentions replacing chlorinated hydrocarbons, petroleum naphthas, and CFC 13 with products having citrus or terpene bases. He also suggests replacing the need for chromium and methyl chloride strippers and surface preparation compounds with alternative coatings and paints, or with cleaner processes altogether such as abrasives or xenon flash lamps. Other techniques to decrease environmental impact include reducing the amount of hazardous material used and recycling whenever possible.

Deicing compounds. Most deicing compounds used today are glycol and water mixes. Ethylene glycol may be lethal in relatively small amounts (less than 5 mg),[41] if consumed by a human or animal. Capturing and recycling ethylene glycol is common in fixed-stand deicing situations; otherwise, it becomes a storm drain environmental problem.

Fuels and flammables. Although jet fuel is the most common fuel found in the aviation maintenance environment, tanks of compressed gaseous fuels [such as Liquefied Petroleum Gases (LPG)] are also present. It is appropriate to control access to these fuels and to protect storage tanks from moving equipment, static discharge, unauthorized use, and corrosion. Internal volume or pressure sensors, external leak detectors, or diligent daily volume measurements such as "sticking the tank" help detect leaks.

Minimize the areas where gases can collect, such as in small rooms or under walkways that cross fueling areas. Small quantities of flammable liquids - paints, solvents, or fuels - are best stored inside a building in double-walled metal or other suitable fire-resistant cabinets (OSHA 1910.106(d)(3)). Larger quantities should be stored outside in an appropriate shed away from other operations. Segregate compressed gases-such as oxygen, argon, hydrogen-to reduce problems with leaking, contamination, or misuse.

Storage. Even otherwise non-hazardous materials sometimes become hazards because of how they are stored. Storage areas can be inadequate when the hangar's floor plan is largely open. Scrap, parts to be modified, or incoming parts, components, and subassemblies might sit on the hangar floor in temporary storage. These create hazards for anyone moving work support platforms or material handling equipment around the hangar. They can also block emergency egress. It is better to create holding or staging areas segregated from other operations by secure personnel and equipment barriers such as fences and railings.

Racks used for storage must be stable and strong enough to hold their loads. It should be easy visually to check the contents and select what is needed. The highest shelf should be no higher than the eye height of the shortest person. Stacked materials can fall over if stacked too high or for too long. Unmarked containers are especially dangerous and should not be used, even for temporary storage of non-hazardous materials.

Administration/Organization Issues

As with any work-related topic, workplace safety has a number of associated administrative or organizational issues. These issues can have as much effect on worker safety as any of the more direct elements we have described earlier in this section. In fact, administrative issues by their nature tend to have very broad effects, generally applying across the entire maintenance organization instead of to a specific group. We address the following issues in this section:

- Record keeping
- Shiftwork and scheduling
- Warnings/Signs
- Work breaks
- Monitoring/Work pace/Standards
- Incentives

- Overtime
- Committees
- Catastrophes/Emergencies
- Lockout/Tagout
- Bloodborne pathogens
- Smoking policy
- Confined space entry.

Record keeping. The most frequent OSHA citation involves inadequate recording of injuries and illnesses. Title 29 CFR (Chapter XVII, Part 1904) requires the following documentation:

- Log and summary of injuries and illnesses (OSHA Form 200)
- Supplementary record of each case (OSHA Form 101)
- An annual summary of all cases to be posted throughout February of the following year (OSHA 200-summarized).

Shiftwork and work schedules. Most aviation maintenance operations involve considerable night work with twenty-four-hour operations being typical. There is concern about the effects of both short- and long-term exposure to non-day work. Tepas recently reported, "We are concerned about the machinist or the industrial worker who has been working the night shift for five, ten, or possibly twenty years. This is a chronic exposure."[42]

The major problems associated with non-day or rotating shift work are cumulative sleep loss and circadian disruption.[43] These can lead to decreased alertness, impaired performance, and emotional mood shifts. Serious disruptions of hormone secretion, digestive processes, and other basic physiological activities can lead to further, even more serious, problems.

Countermeasures to these scheduling effects include appropriate job design, selecting suitable employees for the job, and monitoring them for developing problems.[42] It is also effective for management and labor jointly to address any scheduling concerns and options. This topic is covered in detail in Chapter 4.

Warnings and signs. Provide warnings or instructions whenever there is a significant potential for personal injury or property damage, especially if the person affected may be unaware of the danger. To be effective, the warnings and instructions must contain the following elements:

- Clearly identify the hazard(s)
- Describe the possible consequences
- Inform the person what to do or not do.

The sign must attract a person's attention (it must be conspicuous), it must be visible in available light (it must be legible), and it must be understandable to the person affected. Additionally, it must be durable enough to remain effective, often for years.

The underlying standard for warning signs is ANSI Z-535 (Parts 1-5)[44], which was revised in 1997.[45,46] Among other features, ANSI Z-535 specifies that there be no sharp corners on signs, since these could become hazards themselves. Positive recommendations are more effective than negative ones. For example, the statement "Stay behind yellow line on floor" is better than "Do not come near this equipment." Warning signs should be constructed with two "panels," as shown in Figure 3-9. The upper panel should contain a signal word indicating the degree of risk associated with the hazard. **DANGER** denotes that the hazard is immediate and could cause grave, irreversible damage or injury. **CAUTION** in the upper panel indicates a hazard of lesser magnitude. The sign's lower panel provides the message or instructions regarding how to avoid or manage the risk.

CAUTION signs generally mix yellow and black in the two primary panels. DANGER signs should use a mixture of red, black and white to convey the message.

Figure 3-10. Example of motivational technique that might increase stress.

Work breaks. Many of the soft tissue problems associated with maintenance work arise from holding awkward postures for too long. Even standing or sitting still for several minutes can increase discomfort and potential problems. It is necessary to adjust one's position frequently to keep the blood flowing and to avoid cramping or strain. The best work breaks are self-paced, occurring regularly and as necessary, almost subconsciously, as workers monitor their localized blood flow and muscular fatigue.

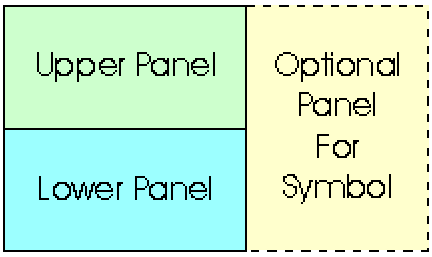


Figure 3-9. Format for warning signs.

Micro-breaks rarely last more than 20-30 seconds, if taken before serious fatigue or cramping occurs. Approximately three longer breaks, i.e., 10 minutes or longer, taken during the course of the day allow workers the opportunity to walk around and stretch in order to "plump up" the intervertebral discs. Longer breaks also provide rest for the eyes, especially if close-focus work is required. Workers should focus at a distance at least 30 feet away during the break to achieve the greatest rest benefit.

Monitoring, Work Pacing, and Job Standards. Significant planning and motivational benefits follow when workers know how much work is to be accomplished in a given period. Even recreational activities typically involve scorekeeping. However, there are two problems associated with this tendency when applied to industry. First, it is possible to over-motivate people, causing them to lose efficiency and to act in an unsafe manner. Many injuries - strains and sprains or Cumulative Trauma Disorder - result from this "grin and bear it" attitude. Figure 3-10 shows an example of a sign intended to motivate technicians to work faster but which may only serve to increase stress.

The second problem arises from the enforced mediocrity associated with standardizing jobs and externally pacing the work activities. It is usually more effective to motivate workers properly and then to let them work at their own pace. The pace varies throughout the day and may also change seasonally.

Incentives. Proper motivation is necessary for successful completion of any task. Different people are motivated by different incentives. Some prefer more money in return for additional output; others prefer compensatory time off. A single, common incentive will rarely motivate all members of the work force equally. Avoid over-motivating workers, which can lead to accidents, injuries, or illnesses.

Overtime. Fatigue such as that from working occasional overtime affects people differently. Though everyone has physiological limits, they are rarely reached, much less exceeded. Typical problems associated with overtime are work errors, especially those due to mental mistakes, and disruption of social activities, including family time.[47] Also, there is a decline in work output for each additional hour of overtime worked. It may be useful to view overtime as a symptom of system imbalance. If the overtime recurs frequently or constantly, the work system is seriously out of balance. Examine the system for permanent interventions that alleviate the need for overtime.

Committees. Most organizations have a current interest in increased worker participation. Since there are fewer managers than there were 10 years ago, the workforce is increasingly independent and transient. At the same time, the workplace is also more complex and time-sensitive today.

One technique for dealing with these trends is implementing worker committees to evaluate working conditions and to recommend improvements. This usually requires someone with specialized training in group dynamics, but provides the organization with motivated employees and superior internal communications.

Two recent National Labor Relations Board (NLRB) decisions (pertaining to Electromation and Du Pont) have confused many people concerned with the legality of committees. These decisions address the unfair labor practice of setting up "sham unions" controlled by management to dominate or interfere with legitimate labor organizations. If a committee simply collects information and explores issues and opportunities for improving the workplace, but does not negotiate specific recommendations with management, then it is an *ad hoc* committee and not an illegal labor organization.[48]

Catastrophes and Emergencies. There are numerous calamitous events that can disrupt operations, place people in jeopardy, and threaten equipment or facilities. These events include fires, explosions, floods, hurricanes and tornadoes, earthquakes, serious work accidents (and their resulting rumors), hazardous material spills, and terrorist acts or civil strife.[49]

Advance planning is necessary to address these events and to reduce their consequences. Such planning involves command and communication procedures, selection and training of response teams, emergency equipment, sheltered areas, alarm systems, evacuation and transportation, on-site security, and coordination with groups outside the organization.

Lockout/Tagout. When a worker is servicing a piece of equipment or a system, it is important to control against undesirable release of hazardous energy that could injure someone or damage equipment. The general procedure to control this energy includes the following steps:[50,51]

- Train all workers involved in the maintenance process so that they understand the equipment or system to be maintained and the lockout/tagout process
- Notify everyone who may be affected
- Shut off all power sources
- Put a tag on the controls to explain why they are to be left off
- Disconnect all primary energy sources such as electrical, hydraulic, or pneumatic lines
- Lock out these energy sources, using multiple locks with unique keys if the work is done by a team
- Control or release all energy from secondary sources such as capacitors, counterweights, or pressure tanks
- Verify the lockouts
- Remove the tag(s) and lock(s) after completing the work
- Notify everyone affected when the work is completed.

First Responders/Bloodborne pathogens. During an emergency there is little time to consider how to protect the first responder team members (or other employees), especially from bloodborne diseases such as Human Immunodeficiency Virus (HIV) or Hepatitis. Prior to having an emergency, an organization should develop a written plan to control exposure to these organisms and to minimize any residual effects.[52,53] The plan should include the following details:

- Training for the first responders
- Engineering and work practice controls
- Required personal protective equipment
- Warning signs and labels
- A case management program subsequent to an exposure event, including vaccines, record keeping, and follow-up.

Smoking policy. Many organizations have smoking policies, but these are usually meant to protect workers only from the effects of second-hand smoke. There are other important health and safety smoking effects. As many smokers have noticed, one's hands become cooler after smoking a cigarette as a result of decreased blood flow to the extremities. This could increase the risk of soft tissue injuries, such as Carpal Tunnel Syndrome.

Another potential problem with smoking in the workplace is the concentration and heat-activation of volatile toxins present in the air. Coupled with the increased risk of fires and the general health consequences associated with smoking, these risks weigh heavily on the side of all organizations implementing a smoking cessation program.

Confined spaces. Bodily entry into any space with limited means of entry or exit not designed for continuous occupancy requires written procedures, prior training, and safety equipment.[54] Some confined spaces have other hazards present, such as toxic gases or fumes, electricity, machinery, etc. A recent report delineated the risks associated with fuel cell repair as an example.[55] Confined spaces are considered inherently hazardous even without being associated with other hazards.

The written confined-space entry plan must address the following for anyone entering such a space:

- Receives appropriate training in entering such spaces and in using any safety equipment
- Secures a written entry permit before entering the space if it contains any hazards that could cause death or serious physical harm
- Tests the space for sufficient oxygen and for dangerous gases or vapors
- Ventilates the space before and during entry
- Locks out any connecting lines

- Has the appropriate safety equipment and trained assistance present during entry.

WHERE TO GET HELP

The American Conference of Governmental Industrial Hygienists publishes a catalog of documents, books, and reports useful to industrial hygienists and others involved in industrial hygiene activities. They also publish the list of Threshold Limit Values for many chemicals used in the United States.

American Conference of Governmental Industrial Hygienists

6500 Glenway Avenue, Building D-7

Cincinnati, OH 45211

Phone: (513) 661-7881

The American Association of Occupational Health Nurses coordinates professional activities for nurses throughout the United States involved in occupational medicine.

American Association of Occupational Health Nurses

50 Lenox Pointe

Atlanta, GA 30324

Phone: (404) 262-1162

Web site: http://www.aaohn.org/forum.htm

The largest association of safety engineers in the United States is the American Society of Safety Engineers. They publish a catalog of information available to safety specialists and hold Professional Development Conferences.

American Society of Safety Engineers

1800 East Oakton Street

Des Plaines, IL 60018-2187

Phone: (708) 692-4121

Web site: http://www.asse.org

The professional association of industrial hygienists is the American Industrial Hygiene Association. They provide continuing education for industrial hygienists and a list of industrial hygiene publications. They also conduct public affairs activities and become involved in regulatory issues affecting the profession.

American Industrial Hygiene Association

2700 Prosperity Avenue, Suite 250

Fairfax, VA 22031

Phone: (703) 849-9899

Web site: http://www.aiha.org

Many safety guidelines available to organizations are formalized into standards by the American

National Standards Institute. Although these standards do not have the authority of legislation, they often represent the most useful information available and delineate minimum acceptable performance levels for organizations and individuals.

American National Standards Institute

1430 Broadway

New York, NY 10018

Phone: (212) 354-3300

Web site: http://web.ansi.org.default.htm

The federal government agency charged with general responsibility for environmental issues is the Environmental Protection Agency.

Environmental Protection Agency

401 M Street SW

Washington, DC 20460

Phone: (202) 260-2090

Web site: http://www.epa.gov

The Flight Safety Foundation, Inc. is an international organization dedicated to improving flight safety. This independent non-profit group helps develop programs, policies, and procedures toward this end. It also serves as a clearinghouse for information and holds annual seminars on aviation safety.

Flight Safety Foundation, Inc.

601 Madison St.

Suite 300

Alexandria, VA 22314

Phone: (703) 739-6700

Fax: (703) 739-6708

Web site: http://flightsafety.org

The Human Factors and Ergonomics Society is the professional organization representing human factors/ergonomics specialists in the United States. They coordinate intersociety affairs, continuing education, annual meetings, publications, and regulatory or legislative activities which affect the profession.

Human Factors and Ergonomics Society

Post Office Box 1369

1124 Montana Avenue, Suite B

Santa Monica, CA 90403

Phone: (310) 394-1811

Fax: (310) 394-2410

Web site: http://hsef.org

Email: hsef@compuserve.com

The International Labor Organization, a United Nations agency, seeks to improve labor conditions and, thereby, to raise living standards and to promote economic and social stability throughout the world. Its members represent governments, laborers, and employers. They publish the *Encyclopedia of Occupational Health and Safety* in both English and French.

International Labor Organization

International Labor Office, CH1211

Geneva 22, Switzerland

or

1750 New York Avenue NW

Washington, DC 20006

Many standards developed by member countries become international standards through the auspices of the International Standards Organization.

International Organization for Standardization (ISO)

1 Rue de Varembe

Geneva 20 Switzerland

Phone: 22 74 90 111

Fax: 22 73 33 430

The largest fire protection and prevention association in the United States is the National Fire Protection Association. This non-profit organization has over 32,000 members. It publishes numerous authoritative documents, including the "National Fire Code," which is now consists of 16 volumes and over 12,000 pages.

National Fire Protection Association

Batterymarch Park

Quincy, MA 02269

Phone: (617) 770-3000

Fax: (617) 770-0700

Web site: http://www.nfpa.org

The National Safety Council is the largest organization in the world devoted entirely to safety. This non-profit organization was chartered by congress, but is not an agency of the federal government. It has an extensive safety-related database and holds frequent seminars, conferences, and meetings.

National Safety Council

1121 Spring Lake Drive

Itasca, IL 60143-3201

Phone: (630) 285-1121

Fax: (630) 285-1315

Web site: http://www.nsc.org

Much of the research done by the National Institute for Occupational Safety and Health serves as a basis for the standards enforced by the Occupational Safety and Health Administration.

National Institute for Occupational Safety and Health

4676 Columbia Parkway

Cincinnati, OH 45226

Phone: (513) 533-8236

Web site: http://www.cdc.gov/niosh/homepage.html

The safety consulting, training, and enforcement branch of the federal government is the Occupational Safety and Health Administration.

Occupational Safety and Health Administration

200 Constitution Avenue, NW

Washington, DC 20210

Phone: (202) 523-7075

Web site: http://www.osha.gov

The largest wellness organization in the United States is the Wellness Councils of America. They hold meetings throughout the year, publish information about wellness, and help coordinate and produce local wellness council activities.

Wellness Councils of America

Community Health Plaza, Suite 311

7101 Newport Avenue

Omaha, NE 68152-2175

Phone: (402) 572-3590F

Fax: (402) 572-3594

The World Health Organization provides technical support for international health and safety matters. This United Nations organization administers the "International Health Regulations" and also publishes the "Health and Safety Guides." Catalogs of publications are available on request.

World Health Organization

Avenue Appia

1211 Geneva 27 Switzerland

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EXAMPLE SCENARIOS

The scenarios presented below represent some of the typical human factors tasks one can expect to encounter in the workplace. The purpose of including these scenarios in the *Guide* is to demonstrate how the authors foresee the document being used. For each scenario, we describe how the issues raised in the scenario can be resolved. There is usually more than one way to approach these issues, so the responses given below represent only one path the *Guide*'s users might take.

As a general rule, always start to look for information by using the Search function. There will be instances that you already know where required information is located. However, unless you frequently use specific sections of the *Guide*, you might miss information pertaining to the same issue located in more than one chapter. The Search will allow you to quickly search all chapters simultaneously.

Scenario 1 - Workplace Safety Responsibility

Congratulations, you've just been promoted to Shift Supervisor. Part of your new responsibility is overall workplace safety.

Issues

1. Do OSHA regulations apply to your aviation maintenance activities? If you think they generally

apply, what must you do to comply?

2. On your first night as Shift Supervisor you discover an asbestos label on some old heating ducts in the storage area. What do you do?

3. Should you inform the individuals who work in the storage area about the asbestos?

4. One of your employees tells you they've had recurring pain in the shoulders for the last three weeks. You tell them to avoid reaching overhead for the next three days. Is this an OSHA recordable situation?

Responses

1. The REGULATORY REQUIREMENTS section hopefully makes clear that OSHA regulations affect every working person in the United States. Some employees are exempt from these regulations. However, even if your workplace is excluded by law from direct involvement with OSHA, the standards form a body of knowledge that cannot be ignored if you are concerned about work place accidents, injuries, and illnesses.

The READER TASKS and GUIDELINES sections address what one should do to develop and implement a safety program. Generally, you should implement the following activities to reduce risks and to comply with OSHA's and other agencies' regulations:

a) develop a written program specifying in tent, responsibilities, and methods

b). survey all working areas and operations for hazards

c) train everyone affected in how to reduce the risks and manage consequences

d) implement changes to mitigate the hazards

e) monitor for new hazards.

2. The *Guide* doesn't directly address the procedures that should be implemented to isolate and evaluate potentially hazardous materials. In the "Evaluating Potential Safety Hazards" subsections, we discuss some of the techniques that can be used to analyze certain jobs, tasks, or environmental characteristics that might pose safety hazards. Since asbestos, the material in question, has such a high profile as a hazardous material, you would probably seal off the area, if practical, and notify management.

3. The regulations regarding informing employees about hazardous materials are clear, as described in the "Materials Issues" subsection. Typically, you or your management would notify all affected employees about this or any other known hazard. Wouldn't you want to know?

4. The "Administration/Organization Issues" subsection briefly addresses the issue of record keeping. Without further investigation, it is unclear whether this is a work-related injury. However, restricted work activities usually indicate that you should record this as an injury or illness. OSHA Form 200 is the appropriate recording instrument for this type of action.

Scenario 2 - Common Myths

You overhear two employees arguing about safety issues at lunch (Hey, it might happen some day!) and you want to help stimulate their interest and steer it along the most constructive path.

Issues

What would you tell them about the following statements?

1. Injuries and accidents occur because someone is careless.

2. Our company (or organization) should have no interest in an individual's at-home hobbies or general level of health.

3. Driver's training is not really important for adults.

4. We can't buy a special tool for someone, even if they need it, because everyone else will want special attention, too.

Responses

1. The discussion of accident proneness in the CONCEPTS section hopefully makes a clear argument that most injuries and accidents **do not** occur only because people are careless. The statement here implies that people don't care if they are hurt. If they, indeed, do not care, then they are probably suffering from mental illness.

Usually, accidents are caused by a combination of hazards and unsafe behavior. The unsafe behavior may be caused by a number of factors including reduced fitness (alcohol consumption, inadequate sleep, emotional distraction, or other causes), misperception of risk (mental impairment, inadequate training, or new job), or intentional sabotage. The main point is that there is no real way to deal with carelessness, but we can usually find an underlying issue that can be improved.

2. The issue of trying to influence employee's off-work activities is not directly addressed in this *Guide*. However, it is clear that a person's lifestyle, hobbies, etc., can directly affect his or her on-the-job risk of illness or injury. Companies can try to positively influence employee's lifestyles in a number of ways. For example, company-sponsored smoking cessation programs can help motivated employees stop smoking.

Hearing loss is another area in which companies can have a more direct effect on employee behavior. Originally, organizations felt they could do nothing about off-the-job hearing loss such as that from running chain saws or attending rock concerts. In time, however, many organizations found that the hearing-conservation training they provided at work transferred to off-work situations, too. Companies that once tried to keep employees from taking their earplugs home might now allow, even encourage, this behavior.

3. Typically, workers are more at risk for injuries while driving to and from work, than from workplace accidents. The "Motorized Vehicles" subsection states that using motorized vehicles, including automobiles, is the most dangerous activity most workers undertake. Automobile accidents will probably continue to be the leading cause of death among working-age people in the United States, and driver's training can reduce these.

4. The "Tool and Equipment Issues" subsection makes the point that tools need to be designed for both the task for which they will be used and for the people who will use them. If someone needs a tool, it is foolish and ineffective to not provide it. Educate your employees about ergonomic principles, and they will understand that different people need different support. If an employee's request seems irrational, it is probably because either they or you do not have enough information.

Scenario 3 - Preventing Back Injuries

One of the new airframe components weighs 62 pounds. It is approximately cubicle, about two feet long on each side, and in smooth packaging. The AMT must position it at waist level during installation.

Issues

1. What is the best way for an AMT to lift this item?
2. How do you measure the Horizontal Location variable, "H", for the NIOSH lifting equation in this situation?
3. What is the difference between the two vertical variables: "V" and "D"?
4. Would this be an example of a "Good" coupling?
5. If the AMT must hold the component to one side during installation, would this be better, or

worse?

Responses

1. The information required to address the issues in this scenario is found in the "Lifting/Manual Material Handling" subsection. The NIOSH lifting formula, shown in Figure 3-5, and the discussion and worksheet related to it indicate that the *maximum* weight that can be lifted by an individual is 51 pounds. Technically, there is no safe way for an individual to lift more than 51 pounds, unassisted. The best way for an AMT to lift this 62-pound component is to get someone else to help.

2. Measure the Horizontal Location variable from the midpoint of a line connecting the inside of the protruding ankle bones to the midpoint of a line connecting the hand grip locations.

3. "V" refers to the vertical height of the hand grip locations, measured at both the origin, or beginning, of the lift and at the destination, or end. "D" refers to the distance traveled by the lifted object during the lift. It is the absolute value of the difference between beginning and ending height of the hand grip locations.

4. This would probably get a poor grip rating, because the component is large and the packaging is smooth, i.e., has no handles or hand grips.

5. This would be an example of asymmetrical lifting. In the lifting equation, the Recommended Weight Limit is reduced when there is an asymmetric lifting component. Therefore, this type of lift will significantly reduce the amount of weight that can be lifted safety.

Scenario 4 - Common Safety Questions

The multimedia safety training program is working well. You know this because this week's Safety Committee Audit Report notes several situations never before mentioned. How will you respond to the following observations?

Issues

1. The noise level in the office area averages 70 dBA, mostly as a result of a printer located in that area. Is it worthwhile to improve this situation?
2. We found a plastic spray bottle with no label. When we checked around, we found out it contained just water. Is this OK?
3. The contractors welding the new guard rails around the storage area leave open the electrical panels so they can hard-wire into the panel. Is a CAUTION sign necessary? Sufficient?
4. We have employees working alone inside a large fuel cell. Is this OK? If I see this person lying still inside the cell should I enter to save them?

Responses

1. The discussion of noise indicates that it is appropriate to reduce noise levels even when they are as low as 65 dBA. Therefore, it may well be worthwhile to reduce the 70 dBA noise level in this scenario, even though it meets the applicable standards. Remember, standards represent the minimum, not the optimal, level of performance in any situation.

This is especially true if a simple, inexpensive change would significantly reduce the noise level, and, therefore, the annoyance, fatigue, and distraction. A simple change might include a sound-absorbing mat under the printer, a reduction in print impact strength (the higher print settings are for multi-part forms, not single sheet printing), or relocating the printer to behind a barrier or sound-reducing panel.

2. While the *Guide* doesn't go into great detail regarding labeling requirements, the discussion in

the "Materials Issues" subsection notes that it is usually necessary to label all containers. This prevents the addition of the wrong material into an unlabeled bottle. It also retains the integrity of the labeling program. In other words, how do I know what's in the bottle if it isn't labeled? Maybe I could drink the liquid, but should not splash it into my eyes or let it mix with another liquid or chemical.

3. This chapter contains a discussion of warnings and signs. The ANSI warning standard specifies the usage of the words "Danger" and "Caution." Since the risk of electrical shock is immediate and severe, you should use a large DANGER sign instead of a CAUTION sign.

4. This fuel cell appears to meet the definition of a confined space (see the "Confined Spaces" subsection). It is not a good idea to have employees alone inside a fuel cell if it meets the definition of a confined space. As noted in the confined spaces discussion, companies should have a confined space entry plan that addresses the number of people required to perform a confined space entry. In general, people should always work in pairs, at least, with one employee outside the space. Do not enter a confined space to rescue someone without the proper safety equipment, which usually includes a breathing apparatus and retrieval mechanism.

Scenario 5 - Cumulative Trauma Disorders

One of your employees has numbness and tingling in his right hand. He wakes up two or three times a week with this hand "asleep."

Issues

Which of the following could contribute to these symptoms? Why? What can you do to reduce the risk?

1. His job requires frequent use of a lightweight pneumatic buffing wheel.
2. He is a champion bowler.
3. His father and brother died of diabetic complications.
4. He prefers to work at shoulder height.
5. He wants to become Shift Supervisor within three years.
6. The hangar is located in a cold climate and remains busy all year.

Responses

The employee's reported symptoms may indicate a Cumulative Trauma Disorder (CTD), such as Carpal Tunnel Syndrome (CTS). Each of the conditions listed in this scenario is thought to contribute to the likelihood of developing Carpal Tunnel Syndrome (or other Cumulative Trauma Disorders).

1. The topic of vibration is discussed in GUIDELINES. Pneumatic tools are the primary source of vibration-induced CTDs.

2. We don't directly address non-work lifestyle issues in the *Guide*. However, any behavior that repeatedly stresses certain muscles, tendons, etc., can be a contributing factor for CTDs.

3. The discussion in the "Fitness/Wellness" subsection addresses chronic conditions such as diabetes. Any condition that is associated with reduced peripheral blood flow can be a contributing factor for CTDs.

4. The "Posture" and "Workstation Design" subsections address this particular issue. Working at shoulder height is an extended, non-neutral posture and can contribute to CTDs.

5. This is a somewhat more subtle issue than the previous four. We're assuming that an individual will work aggressively to increase his or her chances of becoming a Shift Supervisor. This can lead

to over application of force, dangerous postures and quick, ballistic movements - all of which can contribute to CTDs.

6. Working in a cold environment is one of the factors that increases the risk of soft-tissue and musculoskeletal injury. This factor is included in the discussion of "Lifting/Manual Material Handling".

Since the employee's reported symptoms may indicate Carpal Tunnel Syndrome, you should investigate the job activities, equipment, and environment. You would probably also want to educate this employee about the causes, symptoms, treatments, and prevention of Carpal Tunnel Syndrome.

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APPENDIX A

Lifting Analysis Worksheet

Lifting Analysis Worksheet

Department: ______________________ **Job Description:**
Job Title: ______________________ ______________________
Analyst: ______________________ ______________________
Date: ______________________ ______________________

Step 1. Measure and record task variables.

Object Weight (lbs)		Hand Location (inches)				Vertical Distance (inches)	Asymmetry Angle (degrees)		Lifting Frequency (lifts/minute)	Duration (hours)	Object Coupling
		Origin		Destination			Origin	Destination			
Lavg	Lmax	H	V	H	V	D	A	A	F		C

Step 2. Determine the multipliers and compute the RWL's.

RWL = LC x HM x VM x DM x AM x FM x CM

Origin - - RWL = ☐ x ☐ x ☐ x ☐ x ☐ x ☐ x ☐ = ☐ **pounds**

Destination - - RWL = ☐ x ☐ x ☐ x ☐ x ☐ x ☐ x ☐ = ☐ **pounds**

Step 3. Compute the Lifting Index (LI) for origin and destination.

Origin LI = $\frac{\textbf{Object Weight (L)}}{\textbf{RWL}\_\_\_}$ = $\frac{☐}{☐}$ = ☐

Destination LI = $\frac{\textbf{Object Weight (L)}}{\textbf{RWL}\_\_\_\_\_}$ = $\frac{☐}{☐}$ = ☐